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A

PRACTICAL TREATISE

ON

RAIL-ROADS

AND

LOCOMOTIVE ENGINES,

FOR THE USE OF

ENGINEERS, MECHANICS, AND OTHERS;

IN WHICH

THE MECHANICAL CONSTRUCTION OF

EDGE, TRAM, SUSPENSION, AND ALL OTHER RAILWAYS,

AND THE VARIOUS

LOCOMOTIVE CARRIAGES,

DESIGNED FOR RAIL AND COMMON ROADS,

ARE DESCRIBED IN CHRONOLOGICAL ORDER, ACCOMPANIED BY AN ANALYSIS OF THE WHOLE;

INCLUDING

AN EXPLANATION OF EVERY PATENT THAT HAS HITHERTO BEEN GRANTED IN ENGLAND FOR IMPROVEMENTS IN

THE MECHANISM OF LOCOMOTION.

ILLUSTRATED BY NEARLY 250 *ENGRAVINGS.*

BY LUKE HEBERT,

CIVIL ENGINEER AND PATENT AGENT,

EDITOR OF THE ENGINEER'S AND MECHANIC'S ENCYCLOPÆDIA; THE HISTORY OF THE STEAM ENGINE; OF THE REGISTER OF ARTS, AND JOURNAL OF PATENT INVENTIONS, ETC.

LONDON:

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The Treatise now offered to the Public forms the article "Railway" in the *Engineer's and Mechanic's Encyclopædia*; but in consequence of the very numerous applications made for this portion of that work, it has been deemed expedient to publish it in a separate form.

In the composition of the present Treatise, the author has endeavoured to give a succinct historical view of the numerous and important inventions which have been made in the construction of Rail-roads, as well as of Locomotive Engines, illustrated by nearly two hundred and fifty accurately executed engravings and descriptions, by which the reader will be enabled to form a just estimate of their respective merits.

In the selection of his materials, the author has been indebted to the works of Messrs. Wood, Tredgold, Palmer, Walker, Stephenson, M'Neill, Booth, Rastrick, Scott, Lardner, Gordon, and others; to the *Repertory of Arts*, the *Journal of Patent Inventions*, the *Mechanic's Magazine*, the *London Journal of Arts*, and the *Transactions* of various scientific institutions. If, in some instances, he has omitted to acknowledge his authority, it is attributable to the difficulty of fixing the original author. The greater part of the subjects are, however, derived from his own resources, collected in his professional avocations of reporting upon new inventions, and of procuring letters patent for inventors.

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A PRACTICAL TREATISE

ON

RAIL-ROADS,

&c. &c.

RAILWAY or *Railroad*, and *Tramroad;* are narrow tracks of rails, or plates of iron, wood, or other tenacious material, made with very smooth or level surfaces, and laid down with great solidity and truth, to the required planes; so that the wheels of carriages may meet with the least resistance that is practicable in rolling over them, and thus reduce, as much as possible, the power required to move a given load; or to move the greatest load by a given power; or to move a given load at the highest velocity. Rail and tramroads, however, form only one part of the machinery of transport; the carriages which roll over them are expressly designed and fitted for that peculiar office, and are also an essential part of the same mechanism. It is, therefore, not our intention to separate them (as is usually done,) into distinct subjects, but to treat of them in their combined and only useful state. For the same reasons we shall include, under this article, descriptive accounts of the various locomotive carriages for the common road; because these machines require only a slight alteration in the tire of their wheels, to adapt them to railways: and those of our readers who, for want of sufficient consideration of the subject, may have formed an unfavourable opinion of their capabilites, owing to their sluggish pace in passing over loose or hilly ground, would be amazed at the velocity of motion and power of draught they would achieve, if transferred to a railway. It has been ascertained, that the resistance to the motion of a carriage upon a good railway, is not more than a tenth part of that upon a well-made common road; consequently, a carriage that is capable of merely dragging itself along the latter, would draw many times its own weight at a much greater velocity on the former.

The ardour and spirit with which the people, not only of our own favoured country, but those of Europe, and the more enlightened portion of those of Asia, Africa, and America, have set about improving their internal communications, by the adoption of iron railroads, render every circumstance relating to them, that has in the slightest degree contributed to their present excellence, an object of deep interest; not only to the philosopher and the mechanic, but to the thinking part of the public generally. The two former are quite sensible that, notwithstanding all that has been effected, much more is left that *will* be accomplished; and that only a little more practical experience is requisite, to enable us to *double* our present locomotive power. Viewing the subject in this light, it is our intention to give an historical account of all the numerous inventions that have *any bearing* upon the subject, and especially such as have been,

or are now, protected by patent-right; in order, *First*, that engineers and inventors may be informed of the precise nature and extent of those improvements for which exclusive privileges have been fairly acquired by patentees; *Second*, that the inventions of the latter may be fostered and encouraged by public adoption, as far as they may be meritorious and beneficial; *Third*, that such propositions as are erroneous in principle, or inefficient in operation, may be corrected and improved upon; *Fourth*, that "honour may be given to those to whom honour is due;" for in this line of invention there has been an unusual degree of deceitful quackery, and consequently of gross injustice to original inventors; to right whom, in the public estimation, no other advocacy is necessary, than a simple *chronological* statement of public documents, the authencity of which is unquestionable, and which we propose to give in the following pages.

The earliest account we have of the introduction of railways, is in the "Life of the Lord Keeper North," from which it appears that about the year 1670, they were made use of at Newcastle-upon-Tyne, for transporting coals from the mines to the shipping in the river Tyne. At that time, coal came generally into use as a substitute for wood fuel in London, and other places to which there were easy means of transport by sea. But the greatest difficulties were experienced at the mines in conveying the coals from them to the ships in the Tyne. Previous to the erection of these railways, it was no uncommon thing for the occupiers of the mines, to employ five or six hundred horses and carts each, in the same traffic. It therefore became an object of vast importance to adopt some plan of reducing the very great expense incurred in the keeping of so many horses and drivers, wear and tear of carts, and the making and repairing of roads. After giving the subject much consideration, wooden rails, consisting of straight pieces of timber, were laid down and embedded in the road. These were found so advantageous at Newcastle, that they were speedily copied at other mining districts, and remained in use for a considerable period of time. The mode of constructing these rude railways has been thus described. "Plots or slips of ground, of the breadth required for the railway, were marked out, extending from the pits to the river, and either leased or purchased by the owners of the coal works. In some cases it was found necessary to make a considerable variation from the direct line, in order to obviate the inequalities of the ground, and to obtain the most regular and easy descent. And in other cases, where these inequalities were inconsiderable, the roads were carried straight forward, and a regular slope obtained by embankments and cutting. After the ground had been levelled and smoothed, as in the formation of an ordinary road, sleepers, composed of large logs of wood, and cut into lengths corresponding with the breadth of the road, were laid across it, at short distances, and firmly bedded into it, for the purpose of supporting and keeping fast the rails on which the waggon-wheels were to run. The rails were connected end to end, forming two continued lines, running in a parallel direction on each side of the road, and crossing the large logs at each of their extremities which formed the foundation for them to rest upon, and to which they were nailed, or otherwise secured, to keep them in their places. These rails were of course very imperfect, and were rapidly worn away, or broken, by the continued friction of the wheels upon them. In order to repair or reconnect them when their continuity or evenness was destroyed, slips or pieces of timber of a smaller scantling were laid over the dilapidated portions; and the strength which the latter thus derived, led to the introduction of double-rails throughout the line; and this improvement was distinguished by the term of a "double-way," in contradistinction of the former plan, afterwards denominated the "single-way." The advantages of the double-way chiefly consisted in the circumstance that the upper, or covering rail, might be completely worn out and renewed, without destroying or materially disturbing the substructure. The annexed description of these double-ways is obtained from Mr. Wood's valuable work on railways. The subjoined figure exhibits a side elevation. *a a* are the rails fastened down upon the cross sleepers *b b b b*, similar to those of the single-way (which it represents); *á á* the upper rails laid *upon the other, and firmly* secured to them by wooden pins, in the same manner

as the other are fastened to the sleepers. In the single way, the joinings of the rails are necessarily upon a sleeper, as shown at *c c;* but in the double-way it is not so, for, being fastened down upon the surface of the under rail, which in every part presents a proper bearing, they can be secured any where upon it; *d d* show the joinings of the upper rail, which are midway between the

sleepers, but which can be raised at pleasure. This prevents the under rail from being destroyed by the frequent perforation of the pin-holes in receiving the upper or wearing rail, and saves the waste of timber occasioned by use of the single-way.

The sleepers in this description of road were generally formed of young saplings, or strong branches of the oak, obtained by thinning the plantations, and were six feet long by five or six inches in thickness, and about the same breadth. At their first introduction, the under rail was of oak, and afterwards of fir, mostly six feet long, reaching across three sleepers, each two feet apart, and about five inches broad on the surface, by four or five inches in depth. The upper rail was of the same dimensions, and almost always made of beech or plane tree. The surface of the ground being formed pretty even, for about six feet in width from the pits to the staiths, or the whole length of the intended railroad, or "waggon-way," as it was termed, the sleepers were then laid down two feet apart, and the under rail properly secured to them. The ashes or material forming the surface of the ground, were then beat firmly against the surface of the rail, which was thus strengthened and made more rigid. The upper rail was then placed upon the other, and firmly bound down by the pins or pegs of wood.

This combination had many very obvious advantages over the single-rail; for, independent of the waste of timber before alluded to, the destruction of the sleepers in the single-rail by the feet of the draught-horses was considerable. The double-rail, by increasing the height of the surface whereon the carriages travelled, allowed the inside of the road to be filled up with ashes or stone to the under side of the upper rail, and consequently above the level of the sleepers, which thus secured them from the action of the feet of the horses. This description of railroad appears to have continued in use for a considerable period of time, especially amongst the collieries of Durham and Northumberland.

The waggons made use of were pretty nearly on the present construction, but sufficiently large to contain several tons of coal; the wheels, called rollers by some authors, were exceedingly low, the smoothness of the road rendering high wheels unnecessary. An ordinary horse, on these roads, drew three tons of coals without difficulty to the driver. Where any declivity more than usually steep occurred, it was termed a run; and whilst on it, the progress of the waggons was retarded and regulated by a species of crooked lever or brake, managed by the driver, and attached to the waggon. It is stated by some authors, that these wooden rails were subsequently improved upon by making ledges at their sides, to prevent the waggons from going out of their tracks; a form which was subsequently given to them in cast-iron, and termed *tram-plates*, hereafter described. To avoid descending the steep declivities from the high banks at Newcastle to the river, staiths or high platforms are erected, projecting over the river, and so as to be nearly level with the banks; whence the coal waggons are run by a very slightly inclined plane on to these staiths, and there discharged through *shoots or spouts*, either directly into the holds of ships moored

underneath, or into capacious intermediate reservoirs conveniently planned for the subsequent loading of ships.

In most cases the wooden railroads, from the mine to the place of shipment, were made so as to follow very nearly the undulations of the country over which they passed; excepting only here and there at very steep ascents; and for a long period of time no attempts were made to counteract the rapid descent of the carriages down the declivities, except by means of brakes, which, depending wholly upon the strength and dexterity of the waggoners, often failed, and were productive of many sad accidents. Sometimes, owing to the state of the weather, the rails became so slippery, as to render a suspension of the work unavoidable. Frequently, where very steep descents occurred, and a train of waggons were left on the declivity, owing to an obstruction caused by the weather, the falling of a shower of rain would release all the waggons together, and they would descend by their own gravity. Under such circumstances, men were employed to draw ropes across the line of road to arrest their progress; and if this were effected before the momentum became considerable, any very great damage was thus prevented; but if the momentum were sufficient to break the ropes, serious disaster resulted. When cast-iron wheels were first introduced, they were only used for the fore-axle, the wooden wheels being retained on the hind-axle, from the idea that the brake could only be applied effectively to the wooden wheels. At length it was contrived, by an extension of the lever, to apply a brake to the metallic; and then all the four wheels were made of iron. The next improvement was the adoption of iron for wood, which alone enabled the horse to take double his previous load. This change was not first introduced at Newcastle, as is generally supposed, but at the iron-works of Colebrook-dale, in Shropshire, about the year 1767. Our authority for this statement is derived from the reports of a Committee of the House of Commons, on the subject of roads and carriages. It occurs incidentally in a letter to the Committee, from the ingenious Hornblower, the rival and contemporary of the celebrated Mr. Watt; who observes: "Railways have been in use in this kingdom time out of mind, and they were usually formed of scantlings of good sound oak, laid on sills or sleepers of the same timber, and pinned together with the same stuff. But the proprietors of Colebrook-dale Iron Works, a very respectable and opulent company eventually determined to cover these oak rails with cast-iron, *not altogether as a necessary expedient of improvement, but in part as a well-digested measure of economy in support of their trade.* From some adventitious circumstances, (which I need not take time to relate,) the price of pigs became very low, and their works being of great extent, in order to keep the furnaces on, they thought it would be the best means of stocking their pigs, to lay them on the wooden railways, as it would help to pay the interest by reducing the repairs of the rails; and if iron should take any sudden rise, there was nothing to do but to take them up, and send them away as pigs.

"But these scantlings of iron (as I may call them) were not such as those which are now laid in some places; they were about five feet long, four inches broad, and one inch and a quarter thick, with three holes, by which they were fastened to the rails, and very complete it was both in design and execution. Hence it was not difficult, if two persons on horseback should meet on this road, for either to turn his horse out of the road, which, on the railways now introduced, would be attended with some serious doubt as to the consequences. But it would be impossible on the best railways to afford that facility of travelling which we now enjoy on a spacious well-managed road; and in my opinion would prove of greater detriment than all the obstacles we have to deplore in the present uncomfortable state of the roads." We have extended our extract from Mr. Hornblower's letter thus far, to show, that however inadmissible the employment of edge-rails or turned-up tram-plates are on the public roads, the same objection or difficulty of travelling does not apply to the "scantlings of iron" employed at Colebrook-dale; on which point we shall hereafter have some remarks to make.

The introduction of metallic surfaces to the wooden rails was, however, at

first productive of serious evils; for the resistance or adhesion to the surface in descending inclined planes was thereby so much reduced, that the ordinary brake was found to be quite ineffective in counteracting the force of gravity. Recourse was therefore had to the double or self-acting inclined planes, by which *the surplus force of gravity of the load descending one plane was employed to drag up the empty waggons on the ascending plane.* At this period of time the steam-engine was employed in raising mineral from the pits by means of ropes coiled round barrels; the application, therefore, of a similar process to the raising of a train of loaded waggons up an inclined plane became obvious, and was extensively adopted in the north of England.

The introduction of cast-iron plates, having an upright ledge, was originally effected by Mr. Carr, at the Sheffield colliery, about the year 1776. These were at first called plate-rails, but are now usually distinguished by the term tram-plates, from the circumstance of their being used for trams or waggons to roll upon. The form of these, as used in the under-ground colliery at Sheffield, belonging to the duke of Norfolk, is delineated in the following figures. *Fig.* 1 being a plan, and *Fig.* 2 a transverse section of *Fig.* 1, through the dotted line *a b*; *c c* are the plates, 6 feet long, of the sectional shape shown at *c c*, *Fig.* 2;

Fig. 1.

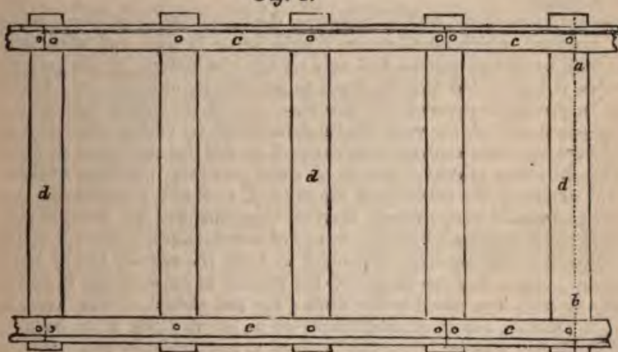
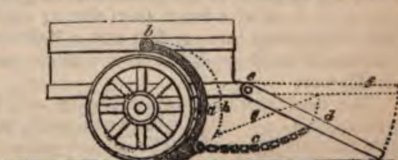


Fig 2.

at each end of the rails holes were cast, through which stout nails were driven into the sleepers *d d d*, made of wood, in the first instance, and afterwards of blocks of stone, by Barnes, Outram, and others.

In many of the railroads where horse-power is employed to draw the carriages, the animal is frequently required to check the velocity of the waggons, so that they may not exceed a certain degree of motion; and when a horse is pressed beyond his power of resistance, he necessarily quickens his pace; if, under these circumstances, he makes a trip, he is almost sure to fall, and then to suffer severe, if not fatal injury, by being forced down the declivity. To prevent such serious accidents, Mr. Le Caan, of Llanelly, in Caermarthenshire, about thirty years ago, constructed a brake of great simplicity, which cannot fail of checking or stopping the carriages under such circumstances, and is therefore deserving of more public notice than it has hitherto received. In the following engraving we have shown the application of this contrivance to a common Welch cart used upon rails. *a* represents the brake, which we have shown as made of iron, it being in the original a very clumsy mass of wood, shod with iron; the shoe or skid ought to be somewhat broader than the tire of the wheels; the top of the brake turns upon a pivot at *b*, and the lower part is *connected by a strong*



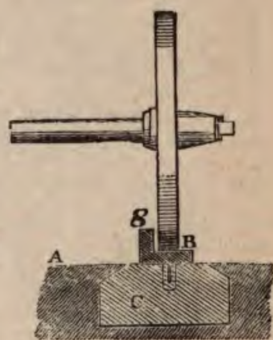
chain *c* to the shaft *d*. The shafts are jointed at *e* to the frame of the cart or waggon; and when the horse is upon his legs, the shaft-chain and brake are in the several positions shown by the dotted lines at *f g h*, the latter, which represents the brake, being then quite clear of the wheels as well as the rails; but when the horse falls the shaft takes the inclined position shown at *d*, and the skid of the brake *a*, by its weight, is thrown under the wheel, which it takes off the rail; the rolling motion is thus changed into a sliding one, and the great friction thus induced either stops the descent of the carriage, or retards it sufficiently to prevent serious injury resulting. In a letter to the Society of Arts, in London, Mr. Le Caan observes:—"To prevent the great trouble arising from turning a waggon round upon a railroad, it would be better to have a brake to each of the four wheels; in which case, after the waggon has discharged its load at the place of destination, the chains *c* may be loosened from the shafts, and fastened upon hooks so as to keep the brakes suspended over the road; the bolt at *e* which attaches the shafts to the body of the waggon, is then to be removed, and, with the shafts, placed in a similar manner on to the other end of the waggon, which now becomes the fore part, the horse drawing it back to be again loaded. Whenever the waggon is ascending, the checks behind the waggon may occasionally be let down and used as rests to relieve the horse when necessary."

In the construction of all surface railways, the first object considered is the direction of the road, which, in all cases, should be so formed, and with such declivity as may be best calculated not only to suit the nature of the ground through which it passes, but also the trade to be carried on upon it. If, for example, as frequently happens to be the case, nearly the whole traffic of a country is in one direction, the road should then obviously decline that way, so that the waggons and their contents may descend on this inclined plane as much as possible by their own gravity. But in all cases particular attention ought to be paid to the extent of the trade upon the railway, so that the inclination may be as nearly as possible proportioned thereto, consequently, the draught each way equalized; and in cases where the transit of merchandize to and fro should be nearly equal, it would be most beneficial to have the railway level: but it sometimes may happen that the nature of the ground is such as not to permit that declivity or level best suited to the trade; the line should, in that case, be varied, and, if possible, the inequalities made up so as to bring it as near as possible to the proper standard, if it can be done at any moderate expense; but when the inequalities happen to be such as to render this impracticable, the only resource to be found is in inclined planes. For example, where the differences of level between the two extremities of road are such as would render an equal declivity too steep, then the road must be carried either on a level, or with the due degree of slope as far as practicable, and then lowered by an inclined plane, on which the waggons are gently let down by a brake, and dragged up by an additional power to that which is made use of for drawing them along the road. But in the laying out and formation of all railways, much depends upon the skill and judgment of the engineer, as it is quite impossible to lay down any general plan to suit all cases; for, it must be recollected, every situation presents some peculiar circumstances. When once the line of railway is fully determined upon, the next step is to form the road, which requires much attention; it must be of sufficient width to contain the opposite rails, and for forming a footpath on one side. There is no prescribed distance between the rails, as, in some cases, preference is given to long narrow waggons, and in others, to those of a broad short shape; consequently, the distance between the rails varies from three to four and a half feet; hence from nine to twelve feet has been usually apportioned for a single road, and from fifteen to twenty for a double one.

The next operation is the placing and firmly bedding the sleepers, which generally consist of solid blocks of stone, weighing from one to two or more hundred weights each. There is no particular shape necessary, provided their bases be broad, and pretty even; it is also particularly necessary that the upper *surfaces should present* an even and solid basis for the iron plates or rails to rest

upon. The sleepers are generally placed along each side of the road, measuring about three feet distant from each other, from centre to centre, the opposite ones being separated by the width between the opposite rails. In such situations, where the ground under them is of a soft nature, it is usual and proper, in the first instance, to lay on a coat of gravel, small stones, or metallic scoriæ; and this is well beaten down in order to form a firm foundation. Each stone, when laid down, is carefully gauged, both in respect to its distance from the adjoining ones, and the level or declivity of its upper surface, on which the plates or rails are intended to rest. The sleepers being thus correctly placed, the spaces between them are filled up with either gravel, metallic scoriæ, or some other hard road materials, in order that the whole may consolidate into a hard and firm mass.

The foregoing is a sketch of the process adopted in forming metallic lines of road, whatever may be the form of the rail or wheel-tracks laid down. Of these, there are two *principal* kinds, namely, tram-plates (already noticed) and edge-rails, both of which are very extensively adopted, though the latter is, at the present time, the most approved by engineers. Nevertheless, it is unquestionable that tram-plates, when correctly *formed*, and laid down with the same attention to accuracy of adjustment and solidity of bearing as is now practised with the best edge-rails, answer their purpose admirably. They are commonly employed in Wales, and in the neighbourhood of blast furnaces, on account of the greater facility and cheapness of their construction. They are especially useful in forming new roads, in the working of mines, quarries, in digging canals, in conveying large stones for buildings, and numerous other temporary as well as permanent purposes; chiefly for this reason,—that the ordinary wheels of carts and waggons can run upon them, and with a surprisingly increased power of draught, while the carriages are kept steady in their tracks, by the upright flanges, as shown in the annexed section, where B represents the flat bearing surface of the tram-plate, which, as now practised, is fastened by a spike, driven into an open plug previously inserted into the stone sleeper C; the horse-path or gravelled road is partly shown at A. These tram-plates are made of cast-iron, are usually about three feet long, from three to five inches broad, and from half an inch to an inch thick, extending from sleeper to sleeper, and the turn-up flange from two and a half to four inches high. The plate usually bears on the sleepers about three inches at each end, where its thickness is for that purpose increased; between these bearing-points the plate has no support but what it derives from the ground, which, though not very permanent or secure, is infinitely more so than the support thus derived by an edge-rail: indeed, the extensive bearing surface of the plate upon the ground is often found quite sufficient for temporary uses, without any sleepers at all; and in other cases, where a little more stability is required, to spike down the opposite ends of the tram-plates, on each side of the road, to a transverse piece of wood, which remains useful for a longer period, without taking up for re-adjustment.



Tram-rails are decidedly of a weak form, considering the quantity of iron in them; and in some works it has been found necessary to strengthen them, by adding a rib on the under side, as shown in the annexed perspective view of a section of half a rail, in which A is the guiding flange; B the bed of the rail on which the wheels run; C is the rib on the under side to strengthen it. The tram-plates used for repairing the Surrey tram-road were of this form, and it certainly renders them very stiff.

12.

The mode of fastening down tram-plates by bolts or spikes was found to be attended with several inconveniences, owing to the occasional projection of their heads, their becoming loose, and hence both the plates and bolts being frequently stolen, to the entire stoppage of the traffic upon the road. To remedy these evils, Mr. Charles le Caan, of Llanelly, in South Wales, contrived a mode of forming the plates, so that no bolting or nailing was requisite, but each plate in succession fastened down the previous one. *Fig.* 1 represents a plan of the junction of two plates, placed on a stone sleeper D; and *Fig.* 2 shows a longitudinal section of the same. The plates are joined by a dove-tailed notch and tenon, and an oblique plug is cast on each plate, which is let into the stone sleeper; but for the advantage of taking up the plates to repair any defect, there are plates at every thirty yards, with perpendicular plugs; such plates are called stop-plates. The diameter of the plug near the shoulder is one inch and three quarters, at the point one inch, its length two inches and a half, and its obliquity, shown in *Fig.* 2, about eight degrees. A small groove in the whole length of the exterior of such plug is made to allow the water in the hole to expand in freezing; and it also serves to admit a wire to draw a broken plug out by it. The holes for the plugs should be cut to the depth of three inches by a standard gauge of cast-iron, and countersunk so as to allow the end of the plate to bed firmly on the block which supports it. *Fig.* 3 is one of the ends of a tram-plate, in which H shows the flange or upright edge; I the flat part or sole, in which the wheels of the waggon run; D one of the plugs; and K a projection behind, to render the plates firmer upon the blocks. The usual length of one plate is three feet; the flanch H is one and a half inch high; the sole, or bed, three and a half, or four inches broad, and three-fourths of an inch thick; but these dimensions are varied according to circumstances. The most approved weight has been forty-two pounds for each plate; the ends from which the plugs project, under which the tenons and notches are made, should be a quarter of an inch thicker than the other parts of the plate. The weight of the blocks or sleepers should not be less than about 120 pounds each; and some kinds of ground will require heavier. In this method the wheels of the waggons cannot be obstructed by the heads of the nails rising above the surface, and the blocks are not disturbed by fixing the plates; and when repairs are necessary, the plates must be formed for the purpose. When tram-plates are fixed by spikes to stone sleepers, there is some difficulty in keeping the joint even and in its place; but it seems to be successfully obviated by using a saddle-pin to receive the ends of the nails at the joints, an improvement which was introduced by Mr. Wilson on the Troon tramroad.

Fig. 1.

Fig. 3.

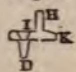


Fig. 2.

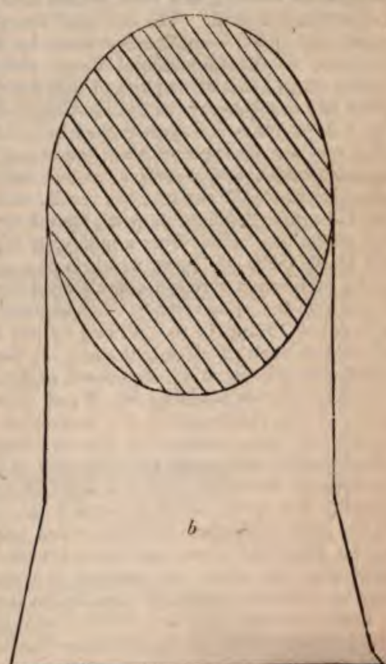
Tramroads are much esteemed in Wales; and in consequence of using them, it is found desirable to divide the pressure upon the rails as much as possible; hence, small carriages are used, and these lead to small wheels, so that the effect of a given power is not above half what it ought to be; and yet the enormous increase of railroads in Wales renders it evident that some benefit is received from adopting this system of conveyance. In 1791, there was scarcely a single railway in South Wales; and in 1811, the complete railroads connected with canals, collieries, &c. in Monmouthshire, Glamorganshire, and Caermarthenshire, amounted to nearly 150 miles in length, exclusive of underground ones, of which one company in Merthyr Tydvil possessed about thirty miles; since which period the lines have been extended to, at the least, three hundred miles.

Whenever it is found necessary for railways to cross any public road, the space between the rails must be paved or firmly causewayed to the level of the top of flanches, in order that carriages passing along the road may be enabled clear over the rails. It is also absolutely necessary, in single railways, to

have certain places formed at intervals, where the empty carriages, in returning may get off the road, in order to allow the loaded ones to pass: a place of this description is termed a turn-out. The waggons are easily directed into it by a movable rail, termed a pointer, fixed at the intersection between the principal rail and the turn-out, and turning on its extremity so as to open the way into the turn-out, and shut that along the road; and whenever one line of railway happens to cross another, this contrivance is also adopted.

The origin of edge-rails cannot easily be traced. The wooden rails partook of this character; for they were generally rounded a little on their upper surfaces, and flanges were put upon the peripheries of the wheels, which, projecting downwards over the sides of the rails, kept the wheels in their tracks; and in some cases square wrought-iron bars were fastened over the wooden rails, partly with a view to strengthen them, as well as to form guides to the wheels: the transition to improved forms was therefore easy. In 1789, Mr. Jessop introduced a cast-iron edge-rail in the public road at Loughborough, the upper surface of which was flat, and the under of an elliptical shape.

It was not, we believe, until the beginning of the present century that *edge-rails* were much known; as it appears that Mr. Benjamin Wyatt, of Lime Grove, near Bangor, imagined himself to have originated them. This gentleman's invention, as applied to the Penrhyn Slate Works, is thus described by himself in a letter to the editor of the *Repertory of Arts*, and is inserted in the third volume of the second series of that valuable work. In allusion to the peculiar rails then in use, he says—"The rail hitherto made use of in most railways is a flat one, three feet in length, with a rib on one edge, to give it strength, and to prevent the wheels, which have a flat rim, from running off. Observing that these rails were frequently obstructed by stones and dirt lodging upon them; that they were obliged to be fastened to single stones or blocks on account of their not rising sufficiently above the sills, to admit of gravelling the horse-path; that the sharp rib standing up was dangerous for the horses; that the strength of the rail was applied the wrong way; and that less surface would produce less friction; led me to consider if some better form of rail could not be applied. The *oval* presented itself as the best adapted to correct all the faults of the flat rail, and I have the satisfaction to say, that it has completely answered the purpose in a railway lately executed for Lord Penryhn, for his lordship's slate quarries in Caermarthenshire, to Port Penryhn, the place of shipping. The wheel made use of on this rail has a concave rim, so contrived in its form, and the wheels so fixed upon their axes, as to move with the greatest facility on the sharpest curves that can be required." It is obvious by the annexed section, which represents the rail, *a*, of its full and exact size, that no dirt can lodge upon it, and that it must be very strong for its weight; and is calculated to resist both the perpendicular and lateral pressure. That it must occasion but little friction, that *it may be placed* upon



the sills so as to admit a sufficient quantity of gravel to cover them, and present no danger to the horse, they were cast 4 feet 6 inches long, and weighed 36 lbs. each. The lower part *b* is cast to each end of the rail, three inches long, to let into the sills, which have a dovetailed notch to receive them.

The Penryhn railway is six miles and a quarter in length, divided into five stages. It has three-eighths of an inch fall in a yard, with three inclines; was begun in October 1800, and finished in July 1801. The annexed sketch shows the kind of waggons that were used on this railway, twenty-four of which, containing 24 tons, were drawn by two horses (one stage) six times a day; which

is 144 tons per day, drawn 6¼ miles per day. This quantity of work was previously performed by 144 carts, and 400 horses: so that *ten* horses will by means of this railway do the work of *four hundred!*

It has been repeatedly proposed of late years, to form a rail, or iron way, upon a portion of the common public road, so as not to rise above the level of the general surface, and thus permit carriages to cross them in any direction, without impediment. The utility of the principle of this arrangement has for some time past been demonstrated by the excellent granite *stone-way* for waggons, in the Commercial Road, and the adoption of the same plan in Friday-street, and other parts of London; for by these rough structures, the effect of horse-power is at the least doubled, or one horse is saved out of every two. If so much has been gained by so slight an improvement of the surface, what may not be expected when ignorance and prejudice shall permit the introduction of such perfect surfaces as iron will afford? There is, however, no need of conjecture in the matter; the results of the actual work upon the Manchester and Liverpool Railway show us, that a force of draught equal to a weight of one pound descending from a pulley, is capable of drawing 200 lbs. upon the rail at 2½ miles per hour, which is the ordinary pace of a cart horse, whose power of draught through a day's work is estimated at 150 lbs. drawn up over a pulley at the same velocity. Consequently, we have $150 \times 200 = 30{,}000$ lbs; or between 13 and 14 tons, drawn by one horse with perfect ease! Whatever admiration such effects might excite in the public mind, they would create no surprise to persons at all acquainted with mechanical science; indeed, it appears from experiments made by Mr. Wood, with a well-constructed model, that the whole of the resistances to the motion of a carriage upon a level railway are capable of being reduced to the five hundredth part of the weight; consequently, one horse would be competent to draw $(500 \times 100 =)$ 75,000 lbs., or upwards of 33 tons! But it is not to be expected that the accuracy of workmanship in a model could be carried into effect, or the expense of it afforded on the great scale; nevertheless, when the numerous little progressive ameliorations which the present extensive practice of our railroad mechanics are daily developing, are taken into account, it scarcely admits of a doubt that a horse may be rendered capable of drawing, at the least, 20 tons.

These remarks have been elicited from us by the perusal of the specification of a patented invention by Jonathan Woodhouse, of Ashby-de-la-Zouch, thirty-three years ago, which unfortunately deprives many of our more modern pro-
-rs of their claims to originality Considering that railroads were quite in
-fancy at the period of Mr. Woodhouse's propositions, they strike us as

remarkably judicious, both in arrangement and detail; and from their perfect originality, they are well deserving of a conspicuous station in the history of railroads, though hitherto unnoticed by writers on the subject. The specification is entitled "a new method of forming a cast-iron rail or plate, which may be used in making iron railroads, or *drags* for the working and running of waggons, drays, and other carriages, on public and other roads; and also a new method of fixing, fastening, and securing such cast-iron rail or plate on such roads: dated February 28, 1803." The following is the description.

"The rail or plate is made of cast-iron, and the upper part or surface thereof is concave; the width of which rail or plate may be increased or diminished as may best suit the size of the wheels of the carriages that may be worked upon the particular roads where the rails or plates are used. The method of fixing, fastening, and securing the iron rails or plates, is to place them on bearings, at convenient distances, which are to be fixed firm and solid in the earth, and to fasten the rails or plates to such bearings with wrought-iron screws, or cutter bolts. The bearings for the rails or plates may be made of timber, stone, or cast-iron, or wood-piles; and if the rails or plates are properly fixed to such bearings with wrought-iron screws or cutter bolts, and the road is made even with the surface of the external or outer edges of the rails or plates, either with stone, gravel, or wood, or any other road materials, the rails or plates will be immovable, and the wheels of the carriages used thereon will pass over the same with facility; and by reason of the concave form and manner of fixing of the said rails or plates, no shock which they can receive (except some wilful force is maliciously used) can injure or break them. These rails or plates may be used on private as well as on public or other roads, with a great advantage, where a multiplicity of business is to be carried on; and by reason of such the concave form, and manner of fixing them, they admit of the wheels of carriages to get upon or from them, with facility in any direction; and the wheels working on those rails will move with great smoothness and ease. The annexed drawings show the cast-iron rails or plates, and the methods of fixing, fastening, and securing them, of which the following are the explanations."

Fig. 1, *a a a a*, show four pieces of the plates or rails laid down in two lines, with their concave surfaces upwards. *Fig.* 2 shows the elevation or end view of the plates or rails, their sectional form, and how they are fixed to the bearings *b b* by means of screw bolts or cutter bolts. *Fig.* 3 is added, to show more distinctly on a larger scale, the transverse form of the concave hollow plates or rails. *Fig.* 4 shows the side views of the rails *a a*, with their bearings *b b* under them; the same being shown in a position at right angles in *Figs.* 2, 7, 9, and 11.

Fig. 3.

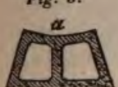


Fig. 1.

Fig. 2.

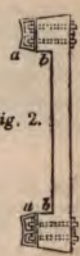


Fig. 4.

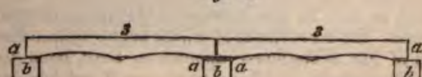


Fig. 5 *exhibits a plan or section of the base or under side of the rails; the recesses c c, in the feet of the rails*, being made to receive the wrought-iron

screws or cutter bolts, which serve the double purpose of preserving and securing the rails in a direct line with each other, and of firmly securing them on their respective bearings: *d d* show the stays cast between the sides of the rails or plates, which brace them together at their bottom edges. *Fig.* 6 shows the

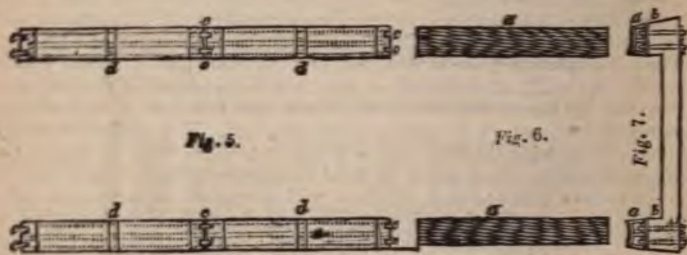
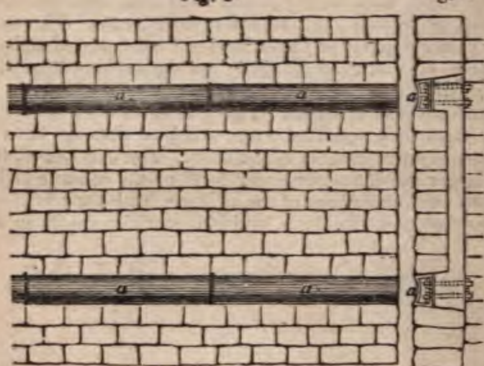


Fig. 5. *Fig.* 6. *Fig.* 7.

diced or checquered rail. These, it is proposed, may also be laid in sheets, and where roads meet or cross each other, to prevent the feet of the horses from slipping, and will therefore be more particularly useful in such roads as have a declivity or descent. *Fig.* 7 exhibits an end elevation of the same.

The subjoined sketch, *Fig.* 8, shows a plan, and *Fig.* 9 a section of the mode of applying the invention to a street or road paved with stone.

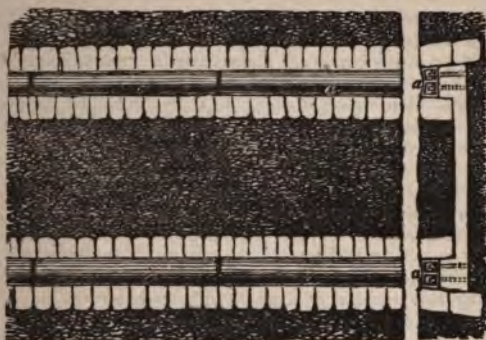
Fig. 8. *Fig.* 9.



Figs. 10 and 11 show in like manner, by a plan and section, the application of the invention to a street or road made of gravel, broken stone, or other road materials; but with the view of keeping the rail or plate as free from gravel as possible, a course of stones is laid on each side of the rail.

In some remarks made by the inventor "on the advantages of concave iron-roads," he observes, that with *two* horses the mail coaches might be conveyed eight miles per hour, as easy as the *present* mails are conveyed six miles per hour with *four* horses; the correctness of which seems unquestionable. One of the leading objects of Mr. Woodhouse appears to have been to avoid the frequent necessity, great expense, and inconvenience of making deep cuttings and embankments, in order to conduct canals into towns, which he proposed to connect by the application of these concave rails to ordinary roads.

Our London readers will not fail to remark, that the cast-iron gutters now laid on each side of most of our public streets are similarly constructed to Mr. Woodhouse's concave rails; and although they are now so modified as to adapt them as water conduits, it may often be observed that the London carmen purposely avail themselves of them as a railway, to ease their horses when heavily



burthened, which it evidently does considerably, although the advantage is gained only upon one side of the carriage. The smoothness of surface which these rails or gutters acquire by the traffic over them, might cause the wheels of a steam carriage (or such as carry their own motive force within) to slip a little; but when the carriage is drawn, as by a horse, the wheels cannot slip round, and the smoothness then becomes an advantage.

The important improvement effected on the Penryhn Railway, by Mr. Wyatt, described at page 13, naturally led to ameliorations in the structure of similar

Fig. 1.

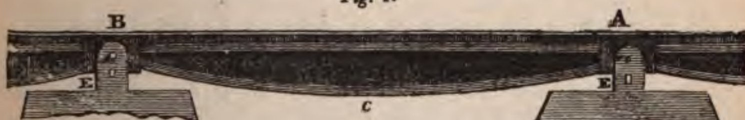


Fig. 2.

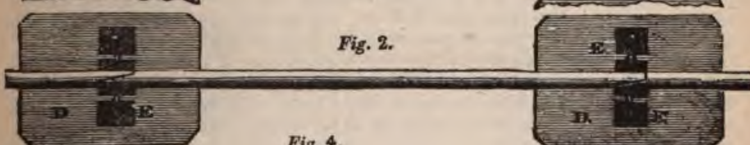


Fig. 4.

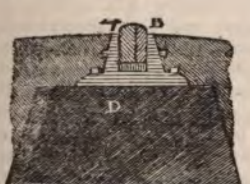


Fig. 3.

works elsewhere, which was especially observable on the banks of the Tyne and Wear. *The expense of the transit* of coals forms so considerable a proportion

of their money cost, that the owners are always alive to any decided saving that may be effected therein. In the engravings in page 17, *Fig.* 1 represents a side view, *Fig.* 2 a plan, and *Fig.* 3 a cross-section of a *cast-iron* edge-rail, of the form which has been extensively adopted in the districts above mentioned. The waggons run upon the rounded edge of the rail, which is smooth, and laid as evenly and regularly as possible. The length of these rails is usually three feet, with a depth of about four inches and a half in the middle, and breadth of the top two inches; but in some railways the rails are four feet long. The ends of the rails meet in a piece of cast-iron, called a chair (see *Fig.* 4), and the chairs are fixed to stone blocks or sleepers, with a broad base, and weighing from one and a half to two hundred weight. These are firmly bedded in the ground, and adjusted to a proper plane for the road before the chairs are connected to them. The goodness of the road of course depends much on fixing the sleepers in a sound, firm manner. In *Fig.* 1 the side view of the rail C is shown, supported at the extremities A B by cast-iron chairs E E, which rest on blocks of stone D D, called sleepers. *Fig.* 2, the plan, shows the scarf joints, where the ends of the rails meet in the iron chairs E E. *Fig.* 3, the cross section of the rail taken at C, in *Fig.* 1, which is the middle of its length. *Fig.* 4 is a cross section at B, through the joint chair and supporting blocks.

Up to the period to which our present history of railways relates, it does not appear that any other power of draught or propulsion was employed but that of horses, and, occasionally, of fixed engines up inclined planes.

In the year 1802 Messrs. Trevithick and Vivian invented and took out a patent for the first locomotive steam-engine, which was, in the second year afterwards, brought into practical operation. The merit of the first suggestion of steam-carriages has been attributed to different individuals; but the probability is, that the idea of applying the steam-engine for the purposes of locomotion was coeval with its first invention. Thus Savery, from having considered its possibility, and Dr. Robison, from having suggested it to Watt, have by some been regarded as the inventors; but almost as well might we regard the philosophic poet Darwin to have been the inventor, who prophesied—

> "Soon shall thy arm, unconquered steam! afar,
> Drag the slow barge, and *drive the rapid car!*"

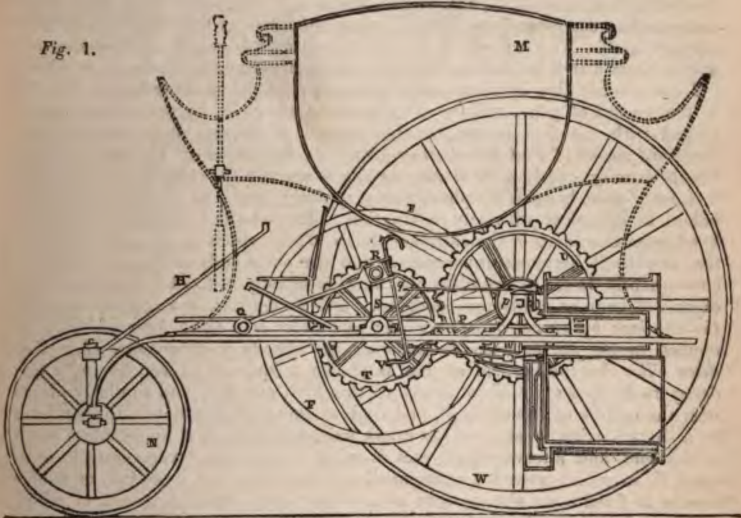
In a note to a late edition of Dr. Robison's *Mechanical Philosophy*, Mr. Watt states,—"My attention was first directed in the year 1759 to the subject of steam-engines, by the late Dr. Robison, then a student in the University of Glasgow, and nearly of my own age. He at that time threw out the idea of applying the power of the steam-engine to the moving of wheel-carriages, and to other purposes; but the scheme was soon *abandoned* on his going abroad." In the patent granted to Mr. Watt in 1784, he gave an account of the adaptation of his mechanism to the propulsion of land carriages. The boiler of this apparatus he proposed should be made of *wooden staves*, joined together, and fastened with iron hoops like a cask. The furnace to be of iron, and placed in the inside of the boiler, so as to be surrounded on every side with water. The boiler was to be placed on a carriage, the wheels of which were to receive their motion from a piston working in a cylinder, the reciprocating motion being converted into a rotatory one, by toothed wheels, revolving with a sun and planet motion, and producing the required velocity by a common series of wheels and pinions. By means of two systems of wheel-work, differing in their proportion, he proposed to adapt the power of the machine to the varied resistance it might have to overcome from the state of the road. A carriage for *two* persons *might*, he thought, be moved with a cylinder of seven inches in diameter, when the piston had a stroke of one foot, and made sixty strokes a minute. Mr. Watt, however, never built a steam-carriage. It is well known that Mr. Watt retained, up to the period of his death, the most rooted prejudices against the use of high steam; indeed, he says himself, "I soon relinquished the idea of constructing an engine on this principle, from being sensible it would be *liable to some* of the objections against Savery's engine, viz. the danger of

bursting the boiler, and also that a great part of the power of the steam would be lost, because no vacuum was formed to assist the descent of the piston."—*Watt's Narrative.*

In a bold deviation from the beaten track, it was the good fortune of Mr. Richard Trevithick and Mr. Andrew Vivian, two engineers residing at Camborne, in Cornwall, to find the path which conducted them to their object;—rejecting the absurd prejudices which had made high-pressure steam to be excluded from practice, they saw in the formidable qualities which had excited the fear of Watt and others, those very properties which fitted it to become the actuating principle of their mechanism. Above all other considerations which swayed them in their preference of steam of a high temperature, was the power it gave of dispensing with the use of the condenser altogether; a part which, from its cumbrousness, and the difficulty of supplying it with water, rendered it far inferior even to Newcomen's imperfect apparatus for locomotive purposes.

The specification of the patent granted to Messrs. Trevithick and Vivian is descriptive of a high-pressure engine, the most simple and effective ever known, which has thus been characterized by the eloquent Mickleham:—" It exhibits in construction the most beautiful simplicity of parts, the most sagacious selection of appropriate forms, their most convenient and effective arrangement and connexion; uniting strength with elegance, the necessary solidity with the greatest portability; possessing unlimited power with a wonderful pliancy to accommodate it to a varying resistance; it may indeed be called THE STEAM-ENGINE." This machine will be found under the article STEAM. Our present business is with the application of this engine, which the specification proceeds to show in connexion with a sugar-cane mill; and, lastly, it describes its employment in propelling "wheel carriages of every

Fig. 1.



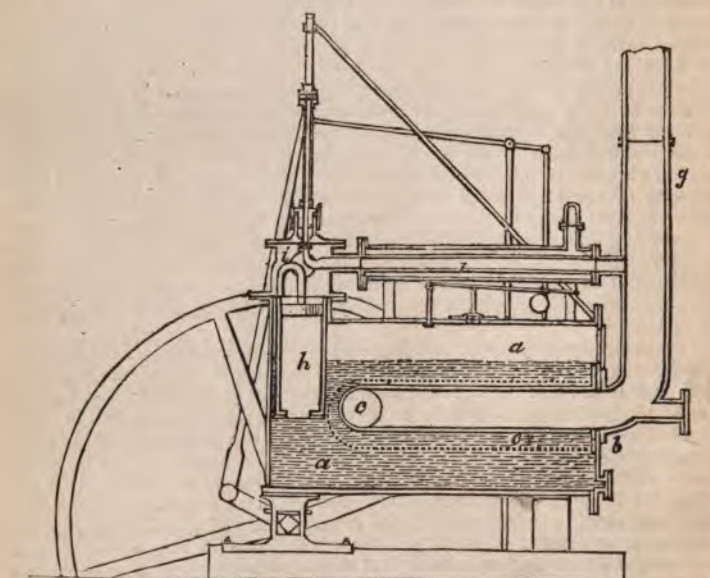
description,"—a purpose for which it is most admirably designed, as it contains generally those arrangements or combinations of mechanism which many of our present locomotionists call their own, and which are adhered to as essential to their machines. We shall now quote from the specification: "*Fig* 1 is a vertical section, and *Fig.* 2 *the plan* of the application of the improved steam-engine

invention in this *steam*-carriage, are in the words following:—"*I claim* the use of *a roller* or *rollers, wheel* or *wheels*, to the upper ends of *my* said propellers, reacting against a straight and smooth rail or plane affixed under, and being a part of the carriage, such rail or plane being parallel, or nearly so, to the soles or bottom of the carriage wheels, whereby the carriage itself is enabled to be rolled over the upper ends of the said propellers, crutches, or feet, by the mechanical power employed." It is worthy of observation, that however a patentee may be disposed to vaunt and puff before the "enlightened public," there is too much risk attending the making of unfounded pretensions in the specification of a patent, wherein the claims to invention *must* be *exactly* defined; for if *any* thing be claimed that is not new, the whole patent is thereby rendered void. In the *claims*, therefore, of a specification, we look for the naked truth; and in this case we find it to be *not* a steam-carriage, but a useless *roller* put under the body of the vehicle! These appendages, however, of guide rollers, it may be remarked, were first applied to preserve the rectilineal motion of the piston-rod in the beautiful high-pressure engines of Trevithick and Vivian, and they have been applied in a thousand similar ways ever since. Mr. Gurney thinks, however, that nobody put rollers to their crutches before him, and that, consequently, he invented *steam*-carriages. And can it be for proposing to use these crutches, which it is notorious were long before patented and used, and found wanting, (by Brunton, in 1813, Baynes, in 1820, Gordon, in 1824, &c.) that Dr. Lardner scatters to the winds all the skill and talent, not only of the gentlemen we have named, but of all others who preceded Mr. Gurney in the building of steam-carriages! The inquiry naturally follows, what became of the celebrated crutches of "the powerful genius?" To answer it, we have referred to Mr. Alexander Gordon's interesting *Treatise on Elemental Locomotion*, and we there find it stated at page 55, that they were "entirely abandoned, the wheel being found not only to be sufficient for impelling the carriage, but also to allow considerable free traction." Now it is of importance to notice, that although Trevithick and Vivian stated in the plainest language in their specification, twenty-four years prior, that the ordinary wheels alone were sufficient to propel; Dr. Lardner and other writers, nevertheless, lead their readers to suppose that Trevithick and Vivian were the authors of this error. At page 247 of his *Treatise*, the Doctor observes,—"The mistake which so long prevailed in the application of locomotion on railroads, and which, as we have shown, materially retarded the progress of that invention, was shared by Mr. Gurney. Without reducing the question to the test of experiment, he took for granted, in his first attempts, that the adhesion of the wheels to the road was too slight to propel the carriage. He was assured, he says, by eminent engineers, that this was a point *settled by actual experiment*. It is strange, however, that a person of his quickness and sagacity did not inquire after the particulars of these actual experiments. So, however, it was; and taking for granted the inability of the wheels to propel, he wasted much labour and skill in the contrivance of levers and propellers, which acted on the ground in a manner somewhat resembling the feet of horses, to drive the carriage forward. After various fruitless attempts of this kind, the experience acquired in the trials to which they gave rise, at *last forced* the truth upon his notice, and *he* found that the adhesion of the wheels was not only sufficient to propel the carriage heavily laden on level roads, but was capable of causing it to ascend all the hills which occur on ordinary turnpike roads." This unqualified admission, by Dr. Lardner, of the entire uselessness of the only invention claimed by Mr. Gurney in his patent steam-carriage of 1825, also shows that the Doctor conceived that Mr. Gurney was the individual who "found out" this error of "eminent engineers;" whereas the fact is incontrovertible that hundreds of thousands of miles had been previously travelled with plain wheels upon railways, where the adhesion of the former to the surface is not one-tenth of that upon the common road. It also shows that the learned author was entirely unacquainted with the many plans for locomotion, by numerous ingenious men (hereafter noticed) who never entertained the idea that the adhesion of the wheels upon the surface was insufficient to propel. And *thus it appears that he*, whose brilliant talents we are told had dispelled an age

lever comes to be disengaged, it suddenly draws *p* back, and turns the cock one quarter turn, and performs the like office of placing the horizontal rod of the other extremity of the handle ready for action by its own springing-lever. *These alternations perform the opening and shutting of the cock*, and to one of the springing levers is fixed *a small force-pump w, which draws hot water from the case by the quick back-stroke, and forces it into the boiler by the stronger and more gradual pressure of a lever on the crank axis.* It is also to be noticed that *in certain cases*, make the external periphery of the wheels W uneven, by projecting heads of nails or bolts, or cross grooves, or *fittings to railroads*, when required; and that *in cases of hard pull* we cause a lever, bolt, or claw, to project through the rim of one or both of the said wheels, so as to take hold of the ground; but that *in general the ordinary structure or figure of the external surface of these wheels will be found to answer the intended purpose.* And, moreover, we do observe and declare, that the power of the engine, with regard to its convenient application to the carriage, may be varied, by changing the relative velocity of rotation of the wheels W compared with that of the axis S, by shifting the gears or toothed wheels for others of different sizes, properly adapted to each other in various ways, which will readily be adopted by any person of competent skill in machinery. The body of the carriage M may be made of any convenient size or figure, according to its intended uses. And, lastly, we do occasionally use bellows to excite the fire, and the said bellows are worked by the piston-rod or crank, and may be fixed in any situation or part of the several engines herein described, as may be found most convenient." Such admirable combinations of inventive skill were never before contained in the specification of a patent; yet they are described with that unassuming brevity which belongs to matters of common occurrence. What an extraordinary contrast does the modesty of these truly clever men present, when compared with the boastings of several of our recent locomotionists, who have derived *almost every thing* that is of a useful character in their carriages from the foregoing specification, and from the subsequent practical application of the inventions by the patentees themselves. There are thousands of persons now living in London who saw the steam-coaches of Messrs. Trevithick and Vivian running about the waste ground in the vicinity of the present Bethlehem Hospital; and likewise in the neighbourhood or site of Euston Square. This was thirty-four years ago; nevertheless, Dr. Lardner says, at page 246 of his *Treatise on the Steam-engine*, "First and most prominent in the history of the application of steam to the propelling of carriages on turnpike roads, stands the name of Mr. Goldsworthy Gurney. . . . . Numerous other projectors, as might have been expected, have followed in his wake. Whether they, or any of them, by better fortune, *greater public support*, or more powerful genius, may outstrip him in the career on which he has ventured, it would not perhaps at present be easy to predict. But whatever may be the event, to Mr. *Gurney* is due, and will be paid, the honour of first proving the practicability of the project; and in the history of the adaptation of the locomotive engine to common roads, his name will stand before all others in point of time; and the success of his attempts will be recorded as the origin and cause of the success of others in the same race." We know not to what cause to attribute such an obvious misstatement of facts; for it is impossible for any one who attends to the chronology or history of the subject, not to see at once that there are about as many untruths in this panegyric as there are lines. It is extremely painful to us to make these observations upon a gentleman of such high scientific attainments as the learned Doctor; but his just influence upon the public mind, renders it imperative upon us to notice this common error which he has fallen into, in order that the fairly earned honours of those truly eminent mechanics, Trevithick and Vivian, be not thus sacrilegiously trampled in the dust!

Mr. Gurney's first patent for a *steam*-carriage was in the year 1825, and will be found described in its proper chronological position. We will, however, in this place, merely observe, that the mechanic who peruses the said specification, will instantly recognise the chief arrangements of Trevithick and Vivian; and if he reads on to the *end of the* specification, he will find that the sole claims to

purpose!" All comments on such facts are unnecessary; we therefore proceed to give the reader another and very early modification of Messrs. Trevithick and Vivian's patent locomotive carriage, as it was applied upon a very indifferent tramroad; in which carriage, as in the former, the propulsion was effected solely by the adhesion of plain wheels upon the trams; nevertheless, on its first trial, it drew ten tons of bar iron after it, besides the carriages, for nine miles, at the rate of five miles an hour, without stopping once, and, therefore, carried beside, a heavy load of water and fuel. The *minor* arrangements of this carriage have been variously described by different authorities, owing probably to the circumstance that several carriages were built at the time, possessing these variations; but the following vertical section conveys all that seems to be essentially required. The boiler *a a* is cylindrical, with a fire-door at *b* at one end of the cylinder; at *c* is the fireplace, from which is the principal flue, the parts being shown by dots, as they are supposed to be situated on one side of the vertical plane, through which our section is made; which will be perfectly understood by reference to the plan of the fireplace and flues given in our



account of the *Sans Pareil* engine by Hackworth. The flue, therefore, is turned at *e*, then recurved, and continued to the chimney *g*. By this excellent arrangement (invented by the patentee, and which has ever since been distinguished by the name of the *Trevithick* boiler) a great economy of fuel was effected, as the greater portion of the heat must inevitably be taken up by the water. The lower part of the working cylinder *h* is immersed in the boiler, and the upper has a jacket. around which the fresh hot steam circulates freely, so that no loss of power can be sustained by the cooling influence of the air upon the cylinder, as was previously the case. Above the cylinder is the four-way cock *i*, for admitting and discharging the the steam alternately; in the latter operation the waste steam was discharged along a pipe *j* into the chimney, which contrivance alone, if now patentable, would make the inventor rich; since its great efficacy in increasing the draught

of air through the fire, causes an increased production of steam, while it gets rid of the nuisance of the waste steam, in a manner so desirable as to render it now of indispensable necessity. The upper end of the piston rod is furnished with a cross bar, which is placed in a direction at right angles to the length of the boiler, and also to the piston rod. This bar is guided in its motion by sliding in two perpendicular rods fixed to the sides of the boiler, and parallel to each other. To the ends of this cross bar are joined two connecting rods, the lower ends of which work two cranks, fixed to the extremities of the axis which carries the running wheels, the axis extending across and beneath the boiler, and immediately under the centre of the steam cylinder: this arrangement is best seen in *Fig.* 1 of the following diagrams, extracted from Mr. Alexander Gordon's *Treatise on Elemental Locomotion; Fig.* 1 exhibiting an end elevation of the carriage, and *Fig.* 2 a side elevation of the same. Mr. Gordon has, however, omitted the chimneys, probably for want of space; and the eduction pipe

Fig. 2.

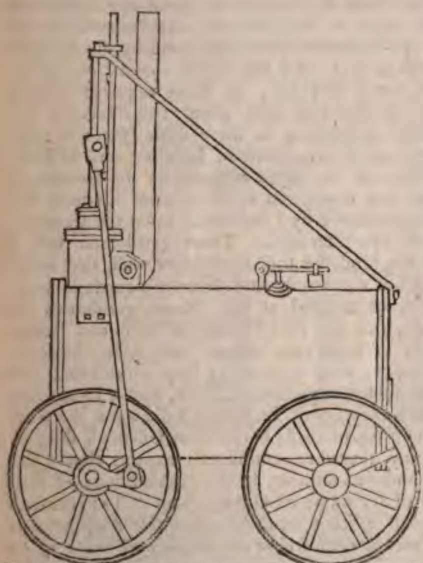
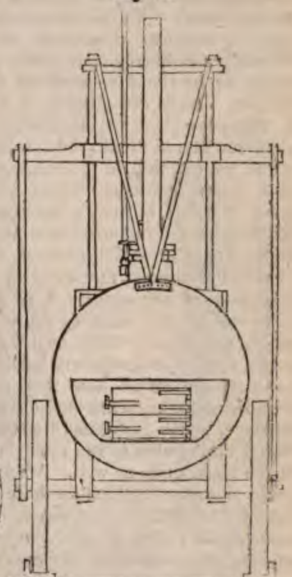


Fig. 1.



is shown as turned up vertically to puff the steam into the air instead of into the chimney; which Mr. Gordon afterwards states was an invention of Mr. Trevithick's, but that the latter had "no intention or expectation of improving the draught in the chimney thereby." From the high respect we entertain towards the author, we regret that such an unfair remark should have escaped him: it is, therefore, with some satisfaction that we observe, on the next page of his book, the following acknowledgment in favour of the true inventor of steam-carriages:—

"It will not be a matter of surprise, that at a period *when turnpike roads were very ill made,* after experimenting on the present site of Euston Square, and a few other places, the inventor discontinued his attempts on common roads, and confined his operations to a railway." Those "very ill-made roads" have now become converted into what the clever Colonel Maceroni aptly denominates "billiard-table roads;" and it is a matter of fact, that Gurney's carriages, made in every *essential* respect after Trevithick's models, did, occasionally, run

upon them; and so did the carriages of many other locomotionists; some prior, some subsequent to Gurney; some decidedly superior to his, and all those that were inferior, were incapacitated from proceeding beyond preparatory trials, by the want of that material with which gentlemen of fortune, then unacquainted with steam locomotion, had so lavishly furnished Mr. Gurney. Notwithstanding all these indisputable facts, we find Mr. Gordon coinciding with Dr. Lardner, in ascribing every thing to the inventive genius of Mr. Gurney; in defiance, too, of their own admission, that the carriage, which they necessarily infer could *not* run (although it *did*, on the site of Euston Square), when transferred to a common Welch tramroad of 1804, drew after it as many waggons in addition as contained ten tons of bar iron, besides a heavy load of water and fuel, making in all probably about 20 tons. This fact being admitted by the authors just quoted, it becomes of importance to show their *consistency*, in stripping the laurels from the head of Trevithick, to deck that of Gurney. By reference to Mr. M'Neill's table of resistances, given by Mr. Gordon at page 337 of his work, it will be seen that upon the best broken stone road (such as Gurney's carriages ran upon) it requires a tractive power of 43 lbs. to move one ton upon a level. To ascertain what force is required to move the same load upon a common tram-road, we refer to Mr. Palmer's experiments on the Llanelly and Surrey tram-roads, the former of which he found by his dynamometer to be one-fifty-ninth of the weight, and the latter one-sixtieth of the weight. Now one-sixtieth of a ton is 37⅓ lbs.; the force required to move a ton upon the last mentioned is therefore only about two-fifteenths less than on Mr. M'Neill's best roads. According to these data (the only data which we can find) it is incumbent on Messrs. Gordon, Lardner, and M'Neill, (the latter gentleman being guilty of the same idolatry as the former) to show that Mr. Gurney's carriage was competent to draw after it, upon Mr. M'Neill's road, the same load as that drawn by Trevithick's upon the tramway, *minus* the aforesaid difference of two-fifteenths. These gentlemen will of course not attempt any thing of the kind, for they must know well, that which thousands of our readers have often witnessed, that Gurney's carriage generally had its full work to do, without any tail at all. These gentlemen will surely not dispute their own data, nor say that Messrs. M'Neill and Palmer made their dynamometers incline to their own views. Let them, however, estimate the errors how they please; they cannot, by *any* established data founded upon authenticated disinterested experiments, show, that a light steam carriage, which performed the work they admit Trevithick's did upon the tram, would not be able to run upon our present roads better than Gurney's did; or, at the least, quite as well. We may, therefore, confidently expect, that a due sense of justice will induce these eminent authors, in the next editions of their valuable works, to insert, instead of the name of Gurney, that "TREVITHICK'S *name stands before all others in point of time, and his admirable high pressure engines and locomotive carriages will be recorded as the origin and cause of the success of others in the same pursuits.*"

We described at page 13, the edge-rail of the Penryhn slate quarries; but it appears from a letter inserted in the *Repertory of Arts*, that the inventor, Mr. Benjamin Wyatt, subsequently proposed to make some alterations therein. It was found that the oval-formed rail had a tendency to wear the concave rims of the wheels away very fast into hollows, which fitted so tight upon the rail as to create great friction, and render it necessary to change the wheels very often. It was accordingly proposed to substitute for them a rail and wheel formed in the manner represented in the annexed drawing. *Fig.* 1 is a section of the rail, rim of wheel, and sill. *Fig.* 2, a plan of one end of

Fig. 2.

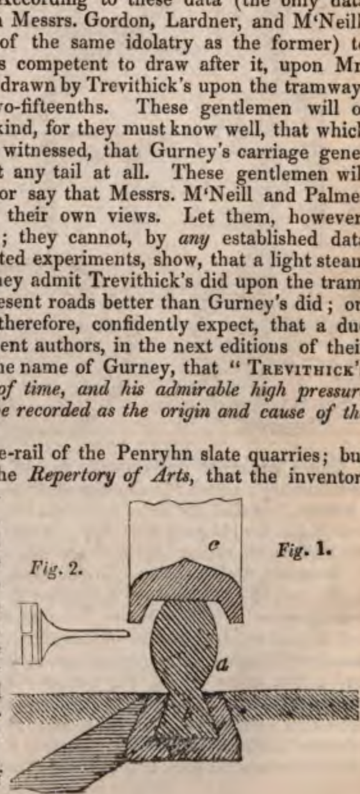
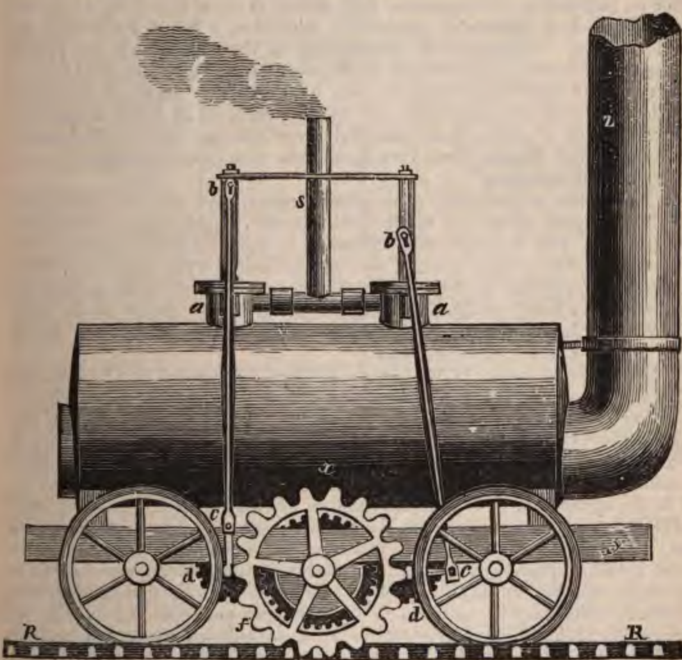


Fig. 1.

sill. *Fig.* 3, section, on a smaller scale, of both rails and sills, which are only two feet apart. The rail *a* is 4 feet 6 inches long; *b* is a flange 2 inches long, cast to each end of thrail, to slide into the dovetail of the sill *e*; *e* is the sill, now of cast-iron; the wheels *c* are also of cast-iron, only 14 inches in diameter, and weigh 38 lbs. each.

In the year 1811, a patent was taken out by Mr. John Blenkinsop, coal viewer, of Middleton, in Yorkshire, for "certain mechanical means by which the conveyance of coals, minerals, and other articles is facilitated, and the expense attending the same rendered less than heretofore." The specification of this patent informs us that it consists of the application of a rack or toothed rail, laid down on one side of the roadway from end to end. Into this rack a toothed wheel is worked by the steam-engine; the revolution of which wheel produces the necessary motion, without being liable to slip in descending a steep inclined plane.

The accompanying figure will convey to our readers an idea of Mr. Blenkin-



sop's plan. The boiler *x* is placed on a wooden or cast-iron frame *y*. Through its interior passes a wrought-iron tube, of sufficient diameter to hold the fire and grate; this tube is carried out at the farther end of the boiler, when it is bent upwards, and continued sufficiently high to form the chimney *z*. *a a* are two working cylinders fixed in the boiler, and which work in the usual way; the piston rods are connected by cross heads to the connecting rods b b. These connecting rods are brought down on each side of the boiler, and there joined

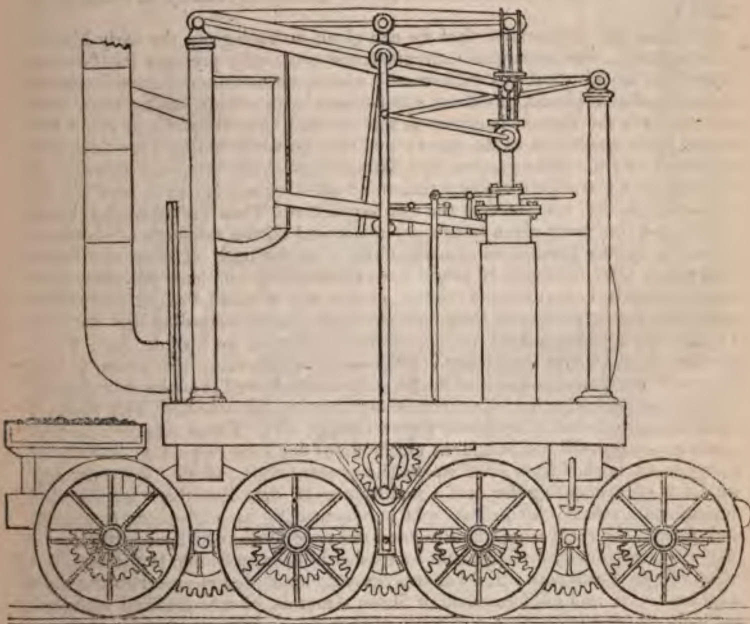
to the cranks *c c*, (there being corresponding cranks on the other side of the machine,) which are placed at right angles to each other; consequently the two cranks on the first shaft are horizontal, and at their greatest power at the time the other two are passing the centre. Upon these shafts are fixed (under the boiler) two small toothed wheels, which give motion to a larger toothed wheel fixed upon an intermediate axis. A toothed wheel *f* is firmly keyed to the end of the same and revolves with the intermediate wheel. The teeth of *f* correspond with, and work into a rack R R, stretched along one side of the railway. Motion, therefore, is given by the pistons to the wheels *d d*, which they communicate to the cog-wheel *f*; a progressive movement being given to the carriage by the teeth of *f* taking hold of the rack.

The only objection made to this machine by Mr. E. Galloway is, "that the power is applied on one side only, which must have a tendency to force the flanges or projecting rims of the supporting wheels against the edges of the rails, by which an extra friction would be produced. This, however, is a trifling inconvenience, and is not found in practice to deduct much from the effect of the engines, several of which have, since the date of the patent, been in constant use in drawing coal waggons between Middleton colliery and Leeds." The ingenious Mr. Galloway observes, that by this machine a load may be drawn up a much greater declivity, than by the locomotive of Messrs. Trevithick and Vivian. But this observation, which appears to be repeated by every author on locomotion in succession, only serves to show, that they never read the specification of those able engineers; otherwise, it would be readily perceived that the "cross-grooved" peripheries of the wheels, and the suitable "*fittings to railroads*," had reference to this very invention of Blenkinsop's. It however seems that those eminent men were not only deprived of the just reward of their labour and talents, but that they were on all hands subjected to the mortification of seeing their beautiful inventions ascribed to after-comers, by whom, or their friends, those very inventions were actually employed to disparage the real inventors!

Mr. Partington, in his history of the steam-engine, says, that Mr. Blenkinsop, in reply to queries put to him by Sir John Sinclair, stated that his patent locomotive engine, with two eight-inch cylinders, weighs five tons; consumes two-thirds of a hundred-weight of coals, and fifty gallons of water per hour; draws twenty-seven waggons, weighing ninety-four tons, on a dead level, at three and a half miles per hour; or fifteen tons up an ascent of two inches in the yard; when "lightly loaded" it travels ten miles an hour, does the work of sixteen horses in twelve hours, and costs 400*l*.

In the following year, 1812, Messrs. William Chapman, of Durham, and E. W. Chapman, of Wallsend, Northumberland, took out a patent for "a method or methods of facilitating the means, and reducing the expense, of carriage on railways and other roads;" which they describe as chiefly consisting in the use of a chain, or other flexible and continuous substance stretched along the road to be travelled, properly secured at each end, and at suitable intervals; and in the application of this chain round, or partially round a grooved barrel or wheel, in such manner as not to slip when this grooved wheel, which is fixed upon, before, or behind a carriage containing the motive power, shall be put in motion by that power, so that by the revolution of the grooved barrel round its axis, either one way or the other, it shall necessarily draw the said carriage, and any others which may be attached to it, within its power of action. As the carriage containing the motive power, when thus loaded, may be too heavy in some instances for the existing iron or wooden rails, if it rested on four wheels only, Messrs. Chapman proposed to use six or eight wheels, in order that they might more freely move round curves in the road, and that the weight might be more distributed thereon; the pressure being thus reduced upon each bearing point, in the inverse proportion of the number of wheels. The means adopted by the patentees for carrying their invention into effect, are described at considerable length, with explanatory drawings, in their specification; but as Mr. Wood informs us that the application of it failed at the Heaton Colliery, where it was for a time put into practical operation, and as the details of it would occupy too

large a space in our pages, if inserted, we shall refer the reader to the enrolled document for them. The cause of the failure just mentioned is stated to have been owing to the waste of power arising from the excessive friction of the chain. There are one or two incidental observations in the specification which ought not perhaps to pass unnoticed. Allusion is made to the possibility of employing *inflammable gas* as the motive power, which, most of our readers are aware, was a few years ago carried into effect by the ingenious Samuel Brown, and which we propose to describe in the course of this article. We also remark, although it is of little moment, that the specification contains the first proposition we have met with for employing the common winnowing machine to force a current of air under the fire-place. The annexed engraving exhibits an elevation of one of the locomotive engines of Messrs. Chapman, which was



employed on the Heaton Colliery. The boiler consists of a large cylinder, of the Trevithick kind, with the furnace and a double or return flue passing through it to the chimney, situate on one side of the fire door; opposite to which is a chest containing the fuel of supply. The steam chamber is a large vertical cylinder, from which proceeds laterally a pipe to conduct the steam to two vertical cylinders, fixed on either side of the boiler. The motion of the piston rods actuated two vibrating beams, to which were appended two connecting rods, whose lower extremities worked two revolving cranks, carrying on their axis, spur geer, which, through the medium of a train of toothed wheels, shown, gave simultaneous motion to all the running wheels. The weight of this engine, with its water and fuel, we are informed was six tons; and it was set to work in December 1812, upon the railway leading from Mr. J. G. Lambton's collieries to the river Wear. It drew after it 18 loaded coal waggons, weighing 54 tons, up a gentle ascent rising $\frac{5}{16}$ of an inch to a yard (or 46 feet in a mile) at the rate *of four miles an hour.* The power of the engine was applied to the

running wheels as already described; and it was found that their resistance to slipping upon the rails was the utmost power it could exert in drawing waggons after it, which in this instance was carried to the extreme; for although the friction was equal to the drawing forward the train of eighteen waggons, *after they were fairly in motion*, it did not overcome their *vis inertia* until after a considerable *slipping* of the wheels of the carriage.

We have introduced this notice of the earliest experiment made with the engine of the Messrs. Chapman, because it exemplifies, in the clearest manner, that precise inclination of the plane upon which the *smooth* wheels of a carriage, bearing a certain weight, will slip round, without advancing the machine. It also proves the *necessity* in such cases of increasing the friction of the opposing surfaces, either by augmenting the weight, or by some contrivance resembling those suggested by Trevithick in his specifications, which Dr. Lardner repeatedly in the course of his work treats as an absurd attempt to remedy an "*imaginary* difficulty."

From all the information that we can glean in tracing out the early history of locomotion, this remarkable circumstance constantly presents itself,—that when Trevithick's carriages with smooth wheels were employed upon levels, or slightly inclined planes, invidious comparisons with others having cogs were made against the former, because, as was asserted, they slipped and could not ascend such acclivities as the latter; and this, notwithstanding Trevithick first suggested by his "cross grooves and fittings to railroads" the very principle of the cogs, in a less objectionable form, and "all other appliances to boot" of the engine and boiler, contained in the said locomotive! Thus Trevithick lost many orders, and they were given to those who adopted all the essentials of his plans, without acknowledgment, and employed them as the basis of their structures. And when, after the lapse of years, it was found out by these *gentlemen* that smooth wheels had sufficient "bite" of the rail in most circumstances, they made that fact appear to be their own discovery; notwithstanding it is stated in Trevithick's specification of 1802, and was confirmed by his practice; which practice they at first condemned with one general voice; and when, at last, they were compelled to practise it also, they endeavoured to make it appear as vastly superior to Trevithick's mode of surrounding his wheels "with heads of nails, bolts, and claws," which he never used at all! These ungenerous proceedings against the most eminent mechanic of his time appear to have been going on unchecked from 1802 up to the present time, 1836. The only way we have of accounting for this circumstance is, that Trevithick was engaged during many years of his patent right in constructing his high-pressure engines and pumps for recovering the drowned mines of Peru, which undertaking he afterwards personally directed, and succeeded in accomplishing, to the astonishment of the Peruvians. He was subsequently appointed engineer to the royal mint at Lima; and on his arrival at South America, he was received with such enthusiastic gratitude, that the lord warden proposed to "erect his statue in silver." The earth now covers the mortal remains of this eminent man; but his memory will never die: for, to use the words of Mr. Gordon, he has left behind him "a name as inseparably connected with high-pressure steam and locomotion, as that of James Watt with the condensing engine and rotary movement."

We now come to the description of a machine of great singularity, and which strongly attests the ingenuity of the contriver, Mr. William Brunton, of the Butterly Iron Works, in Derbyshire, and for which he took out patents. It consists in a curious combination of levers, the action of which nearly resembles that of the legs of a man in walking, whose feet are alternately made to press against the ground of the road or railway, and in such a manner as to adapt themselves to the various inclinations or inequalities of the surface. The following engraving represents this engine, which the inventor called his "MECHANICAL TRAVELLER." The boiler is nearly similar to that which we last ribed. The cylinder *a* is placed on one side of the boiler; the piston rod ojected out behind horizontally, and is attached to the leg *a b* at *a*, and to eciprocating *jointed* bent lever above; at the lower extremity of the

leg *a b*, feet are attached by a joint at *b*; these feet lay a firmer hold on the ground, being furnished with short prongs, which prevent them from slipping, and are sufficiently broad to prevent their injuring the road. On inspecting the drawing, it will be seen that when the piston rod is projected out from the cylinder, it will tend to push the end of the lever or leg *a* from it, in a direction parallel to the line of the cylinder; but as the leg *a b* is prevented from moving backwards by the end *b* being firmly fixed upon the ground, the reaction is thrown upon the carriage, and a progressive motion given to it, and this will be continued to the end of the stroke. Upon the first reciprocating lever is fixed at 1, a rod, 1 2 3, sliding horizontally backwards and forwards upon the top of the boiler; from 2 to 3 it is furnished with teeth, which work into a cog-wheel, lying

horizontally; on the opposite side of this cog-wheel a sliding-rack is fixed, similar to 1 2 3, which, as the cog-wheel is turned round by the sliding-rack 2 3, is also moved backwards and forwards. The end of this sliding-rod is fixed upon the other reciprocating lever of the leg *d e*, at 4. When, therefore, the sliding-rack is moved forwards in the direction 3 2 1, by the progressive motion of the engine; and, when the piston-rod is at the farthest extremity of the stroke, the leg *d e* will be brought close to the engine; the piston is then made to return in the opposite direction, moving with it the leg *a b*, and also the sliding-rack 1 2 3; the sliding-rack, acting on the toothed wheel, causes the other sliding-rod to move in the contrary direction, and with it the leg *d e*. Whenever, therefore, the piston is at the extremity of the stroke, and one of the legs is no longer of use to propel the engine forward, the other, immediately on the motion of the piston being changed, is ready, in its turn, to act as a fulcrum or abutment for the action of the moving power, to secure the continued progressive motion of the engine. The feet are raised from the ground during the return of the legs to the engine, by straps of leather or rope fastened to the legs at *f f*, passing over friction sheaves, movable in one direction only, by a ratchet and catch, worked by the motion of the engine. The feet are described of various forms in the specification, the great object being to prevent them from injuring the road, and to obtain a firm footing, that no jerks should take place at *the return of the stroke*, when the action of the engine came upon

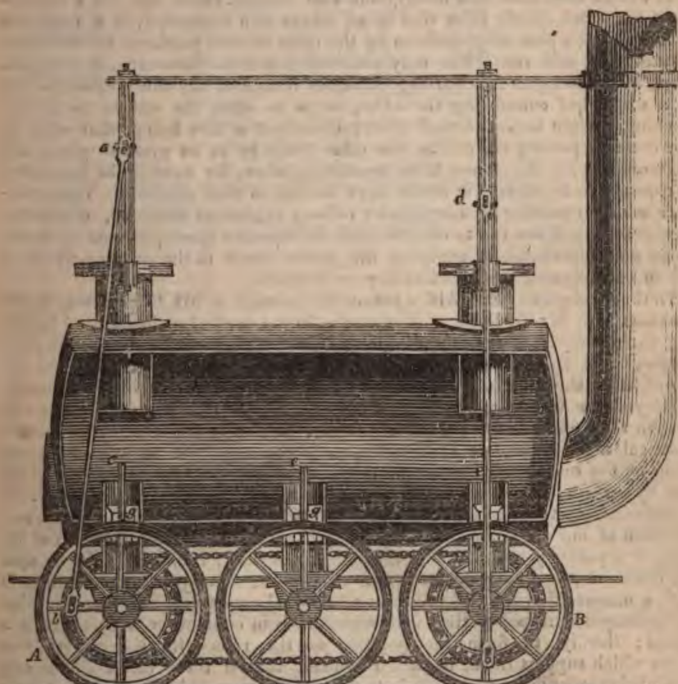
them; for this purpose they were made broad, with short spikes to lay hold of the ground.

It is proper to record that this strange machine was actually put to work. The boiler was a cylinder of wrought-iron, 5 feet 6 inches long, 3 feet in diameter, and of such strength as to be capable of sustaining a pressure of upwards of 400 pounds per square inch. The working cylinder was 6 inches in diameter, and the piston had a stroke of 24 inches; the step of the feet was 26 inches, and the whole machine, including water, weighed about 45 cwt. When placed upon a railway, Mr. Brunton found that it required to move it, at the rate of two and a half miles per hour, a power equal to the constant pressure of 84 pounds. He then applied a chain to the hinder part of the machine, by which, as the machine moved forward, a weight was raised at the same time and rate; and he found that with steam equal to 40 or 45 lbs. pressure upon the square inch, the machine was propelled at the rate of two and a half miles per hour, and raised 112 lbs. at the same speed; thus making the whole power 896 lbs. at two and a half miles, which, at 150 lbs. the horse power, is equal to about six horses; but the machine was only designed to insure 4 horses' power, and to work upon a railway rising one in thirty-six. The late Mr. David Gordon, in 1824, much improved the mode of operating with these substitutes for horses' feet; and Mr. Gurney, in 1825, copied them very closely, as before noticed; both of whose patents will be hereafter described.

Mr. Wood, in his excellent *Treatise upon Railroads*, informs us that, in 1814, an engine upon Blenkinsop's plan (described at page 27, was constructed at the Killingworth Colliery, by Mr. George Stephenson, and tried upon that railroad. In that engine, it will be observed, that the cog-wheels upon the axis of the propelling-wheels are double the diameter of the smaller toothed-wheels, which derive their action from the reciprocating motion of the connecting-rod; consequently, the latter make two revolutions of each one of the cogged propelling-wheels. The experiments were made upon a piece of edge-rail, ascending about 1 yard in 450; and it was found to drag after it, exclusive of its own weight, eight loaded carriages, weighing altogether about 30 tons, at the rate of four miles an hour. The application of the two cylinders rendered the action of the engine regular, and secured the continual progressive motion, thus remedying, Mr. Wood observes, the imperfection caused by the irregular action of the single cylinder and fly-wheel. When the engine had been at work a short time, it was soon *found* that there was sufficient adhesion between the wheels and the rail to propel the carriage; but such was the lingering prejudice, that grooved sheeves were afterwards applied to the hinder travelling wheels of the engine, and similar grooved sheeves upon the fore-wheels of the convoy carriage containing the coals and water; both these were then connected by an endless chain; but this contrivance also was soon *found* to be unnecessary, and the adhesion of the wheels alone produced the desired effect. The communication of the pressure of the steam upon the piston, through the means of the connecting-rod and crank to the cog-wheels, produced great noise, and, in some parts of the stroke, considerable jerks; each cylinder alternately propelling, or becoming propelled by the other, as the pressure of the one upon the wheels became greater or less than the pressure of the other; and when the teeth became worn, they produced a rattling noise. For when the leverage of one crank became greater than the other, the latter was propelled by the other through the intervening wheels; but when the former approached towards the extremity of the stroke, its leverage became less and less, and the leverage of the latter became greater, as the angle between the connecting-rod and the crank increased; and, at a certain point, the latter preponderated. When a change in the action took place, the former was then the propelled, and the latter the propelling power. If any play or space existed between each tooth of the cog-wheels, the transition of this power from one side of the teeth to the other ys occasioned a jerk; and this became greater as the teeth became more 1, and the space between them greater.

ll these inefficient, expensive, and troublesome contrivances, our readers *perceive, were introduced* to obviate "the assumed difficulty," which had

been *demonstrated* ten years before to have no existence. To get rid of the cumbrous wheels and pinions, and avoid the jerks and concussions consequent upon the last mentioned arrangement, we find Mr. Ralph Dodd and Mr George Stephenson, aforesaid, both of Killingworth, taking out a joint patent "for various improvements in the construction of locomotive engines," which was dated February 28, 1815. It consisted of the application of *a pin* upon one of the spokes of the running wheels that supported the engine; the lower end of the connecting-rod being attached to the cross-beam, worked up and down by the piston. (The following engraving serves to explain this invention, although it belongs to the patented improvements subsequently introduced by Mr. Losh, in conjunction with Mr. Stevenson; Mr. Dodd's previous invention being combined therein.) *a b* represents the connecting-rod, the end *a* attached to the cross-beam, and the end *b* to one of the spokes of the wheel; in like manner the end *d* of the other connecting-rod is attached to the beam of the other piston, and the lower end to a pin fixed in the spokes of the wheel B. By these means the reciprocating motion of the piston and connecting-rod is converted, by the pin upon the spokes acting as a crank, into a rotatory motion, and the



continuation of this motion secured by the one pin or crank being kept at right angles to the other, as shown in the drawing. To effect this, the patentees had two methods;—to crank the axles, on which each of the wheels were fixed, with a connecting-rod between, to keep them always at the angle with respect to each other; or to use a peculiar sort of endless chain, passing over a toothed wheel on each axle. This endless chain consisted at first of one broad and two narrow links, alternately fastened together at the ends with bolts; the two narrow links

were always on the outside of the broad link; consequently, the distance they were separated laterally would be equal to the breadth of the broad link, which was generally about two inches, and their length three inches. The periphery of the wheels fixed upon the axles of the engine, was furnished with cogs, projecting from the rim of the wheels (otherwise perfectly circular and flat) about an inch, or an inch and a half. When the wheel turned round, these projecting cogs entered between the two narrow links, having a broad link between every two cogs, resting on the rim of the wheel; these cogs, or projections, caused the chain to move round with the wheel, and completely prevented it from slipping round upon the rim. When, therefore, this chain was laid upon the two toothed wheels, one wheel could not be moved round without the other moving round with it, and thus secured the proper angles to the two cranks. This mode of communicating the action of the engine from one wheel to another, is shown in the drawing, the wheels A and B having each projecting cog-wheels, round which the endless chain passes. When the chain got worn by frequent use, or was stretched, so as to become too long, one of the chains of the axles could be moved back to tighten it again, until a link could be taken out, when the chain was moved back again to its former situation.

It will be seen from this description, that Messrs. Dodd and Co.'s improvement consisted chiefly (like that of all others who succeeded) of a renovation of Trevithick's plan of propulsion by the mere friction produced by the contact of the wheel and rail. The only material difference between the two plans being in the using of two working cylinders, instead of one with a fly wheel; and in a method of connecting the axles, so as to cause the cranks to continue working at right angles to each other; the object of this being, that when the one crank is passing the centre, the other shall be at its greatest power, and consequently aid the former in its revolution, when, for want of the momentum imparted to a fly wheel, it would have to stop in that situation. Upon reference to our engraving of Trevithick's railway engine, at page 20, our mechanical readers will not fail to observe that *the improved* mode proposed by Messrs. Dodd and Stevenson, of applying the power direct to the running wheels, is not to be compared to it in efficiency or durability.

In the subsequent year 1816, a patent was granted to Mr. Stephenson, in conjunction with Mr. W. Losh, of Newcastle, for "a method or methods of facilitating the conveyance of carriages and all manner of goods and materials along railways and tramways, by certain inventions and improvements in the construction of the machine, carriages, carriage-wheels, railways, and tramways employed for that purpose." The specification of this patent is more ably written than such documents usually were; and as it contains much valuable practical intelligence, we shall make some extracts from it, and accompany them by the necessary illustrations. The patentees commence their specification by explaining the distinction between *edge-rails* and the tram or plate-rails, as introductory to their improvements, which they thus explain. "In the construction of our edge-railways, our objects are, first, to fix both the ends of the rails, or separate pieces of which the rails are formed, immovable, in or upon the chairs or props by which they are supported; secondly, to place them in such a manner that the end of any one rail shall not project above or fall below the correspondent end of that with which it is in contact, or with which it is joined; thirdly, to form the joinings of the rails with the pedestals or props which support them, in such a manner, that if these props should vary from their perpendicular position in the line of the way, (which in other railways is often the case,) the joinings of the rails with each other would remain as before such variation, and so that the rails shall bear upon the props as firmly as before.

"In the formation of our wheels, it is our object to construct them in such a manner, and to form them of such materials, as shall make them more durable and less expensive in the repairs than those hitherto in use. This invention we accomplish by forming our wheels either with spokes of malleable iron, and with cast-iron rims, or by making the wheels and spokes of cast-iron, with hoops, tires, or trods, of malleable iron; and in some instances, particularly for

wheels of very small diameters, instead of spokes of malleable iron, we employ plates of malleable iron to form the junction between the naves and the cast-iron rims of the wheels.

Fig. 1 is a side view of the wheels, with wrought-iron arms. *a a a* show the arms cast in the nave, and dropped into mortice holes made in the rim, which are dovetailed, to suit the dovetailed ends of the arms *a a a*. The arms are heated red hot previous to dropping them into the holes, in order to cause them to extend sufficiently for that purpose, for when cold they are too short, owing to the property which iron possesses, of expanding on the application of

Fig. 2. *Fig.* 1. *Fig.* 3.

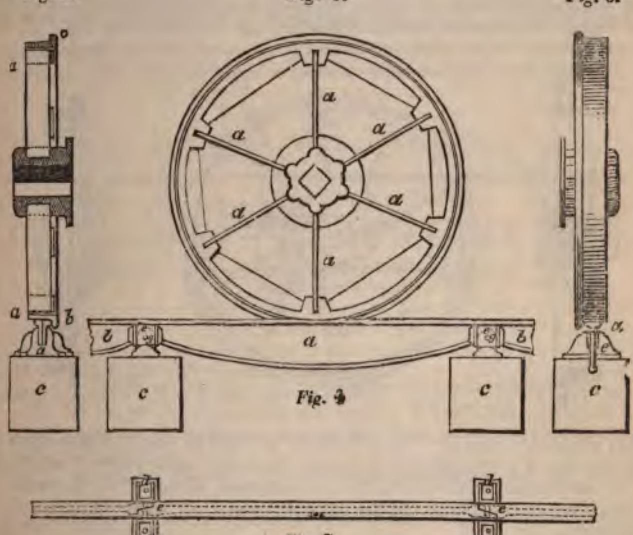


Fig. 5. *Fig.* 6.

Fig. 7.

heat, and of contracting again to its former dimensions on cooling down to the same temperature from which it was raised; the arms, therefore, on cooling, are drawn with a force sufficient to produce a degree of combination between their dovetailed ends and the mortices of the rim, which prevents the possibility of their working loose; they are afterwards keyed up; the mortice holes are also dovetailed, from the tail side of the wheel, (*a a*, *Fig.* 2.) to the crease side (*b* in the same figure.)

Fig. 2 is a cross section through the centre of the wheel, with wrought-iron arms.

Fig. 3 is an end view of *Fig.* 2.

Fig. 4 represents an elevation of the edge railway, showing a rail *a* connected with the two adjoining rails, the ends of which are shown by *b b*, and resting in the props or pedestals, the bases of which are the metal chairs that are bolted to the stone supports *c c*. The joints *e e* are made by the ends of the rails being applied to each other by what is termed a half lap; and the pin or bolt *g* which fixes them to each other, and to the chair in which they are inserted, is made to fit exactly a hole which is drilled through the chair and both ends of the rails, at such a height as to allow both ends of the rails to bear on the chair, and the bearance being the apex of a curve, they both bear at the same point. Thus the end of one rail cannot rise above that of the adjoining one; for although the chair *may move on* the pin in the direction of the line of the

road, yet the rails will still rest upon the curved surface of their bearance without moving.

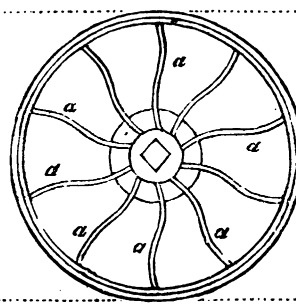
Fig. 5 is a cross section of our edge-railway through the middle of one of the chairs *a*, and across the ends of the two adjoining rails which are connected by a transverse pin; *c* is the stone support or sleeper.

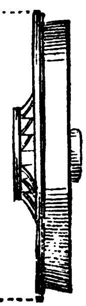
Fig. 6 is a cross section of the rail *a*, at the centre, and shows the carriage *c* behind.

Fig. 7 is a plan of the railway described at *Fig.* 1, showing the half-lap joinings of the rails *e e* placed in their carriages *d d*.

Fig. 8, in the subjoined cut, is a view of the cast-iron wheel with the malleable iron tire. This wheel is made with curved spokes, as shown at *a a a*, and with a slit or aperture in the rim, shown at *b*, into which a key is inserted. The reason of this is, that on the application of the hot tire, the cast metal

Fig. 9. *Fig.* 8. *Fig.* 10.





expands unequally, and the rim is liable to be cracked, and the rims drawn off, unless the first is previously slit or opened, and the latter curved, which allow them to accommodate themselves to the increased diameter of the wheel; by this formation of the wheel, the tire may be placed on when cold, and keyed up afterwards.

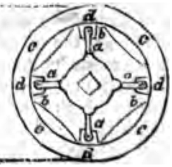
Fig. 9 is a cross section of *Fig.* 8, through the centre. *a a* show the tire; *b b* the metal rim. This cast metal rim is dovetailed; so that when the tire, which is dovetailed to suit it, is put on hot, it contracts, and applies itself to the rim with a degree of adhesion which prevents its coming off from the motion of the wheel on the railway. This wheel is of the form to suit an edge-railway; and to make it answer for a plate-rail, it only requires the rim to be flat.

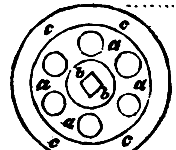
Fig. 10 is an end view of *Fig.* 8 without the malleable iron tire.

We now proceed to the description of the rolley or tram wheels, designed to move upon a plain railway, as illustrated in the subjoined wood cuts.

Fig. 11 represents a view of a rolley or tram wheel; *a a a* are the malleable

Fig. 12. *Fig.* 11. *Fig.* 13. *Fig.* 14.





iron arms, fastened to the projections *b b b* on the inside of the rim *c c*, by the bolts *d d*.

Fig. 12 is a cross section of *Fig.* 11, through the centre of the wheel; *a a* show the arms, *c c* the rim, *d d* the bolts.

Fig. 13 represents a view of a rolley or tram-wheel, with a plate of malleable iron *a a a*, to form the junction between the nave *b b*, and the cast metal rim *c c*.

Fig. 14 is a cross section of *Fig.* 17. *a a* show the plate upon which the nave *b b* is cast; *c c* show the cast-iron rim which is cast upon the plate, the edges of which plate are previously covered with a thin coating of loam and charcoal dust, or other fit substance, to prevent the too intimate adhesion between the iron plate and metal rim, so that if the rim should break, it can easily be taken off, and replaced by casting another on the plate.

Fig. 15 represents Messrs. Losh and Stephenson's plate-railway. At the end of each plate are projections *a a a*, to fit into the dovetailed carriage *b b*, and at each end of each plate are projections or tenons *c c*, which fall into the mortice hole (in *Figs.* 16 and 17) in the carriage *b b*, and secure the rail from an end motion; and when the pin or key is driven into its place, it secures the plates from rising; and they are thus immovably fixed in their carriages.

16.

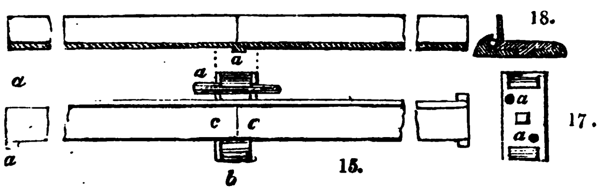


Fig. 16 is a front view of *Fig.* 15.

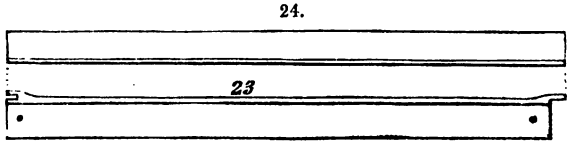
Fig. 17 is a plan of the carriage, in which *a a* show the holes through which the nails are driven to secure it to the sleeper. When the rails are laid in this carriage, and secured by the pin or key, they keep these nails from starting up, by resting upon them.

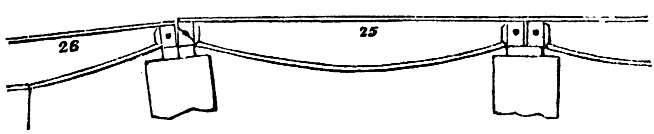
Fig. 18 is a cross section of the carriage, and the end of one of the plate rails.

Figs. 23 and 24 are a plan and front view of a rail of the plate-railway (which was at the date of this patent in common use in the North of England;) our readers will notice the difference between this and those we previously described.

Fig. 25 represents a front view of the edge-railway in common use at New-

24.





castle, prior to 1816; and the portion *Fig.* 26 shows a piece inclining out of the horizontal position, as they very often do from the yielding of the pedestals

the labours of the smith and engineer, and give a higher degree of excellence to the products of their workshops:—

"My invention consists in the adaptation of wrought or malleable iron bars or rails of a peculiar form, instead of cast-iron rails, as heretofore. From the brittle nature of cast iron, it has been found, by experience, necessary to make the bars of a railroad sufficiently strong to bear at least six times the weight intended to be carried along the road, by which the original cost of a railroad was considerably augmented; or if light rails were used, the necessity of frequently repairing entailed a heavy expense upon the proprietors. To obviate these objections, I have invented a bar to be made of wrought, or malleable iron, the original cost of which will be less than the ordinary cast iron rails or bars, and, at the same time, will be found to require little (if any) reparation in the course of many years. The rails or bars which I have invented are formed as prisms, though their sides need not of necessity be flat. *Figs.* 1 and 2 show sections of the bar thus formed; the upper surface upon which the wheel of the carriage is to run is slightly convex, in order to reduce the friction; and the under part rests in the supporting-blocks, chairs, rests, standards, or pedestals, which are mounted upon the sleepers. The wedge-form is proposed, because the strength of the rail is always in proportion to the square of its breadth and depth. Hence this form possesses all the strength of a cube equal to its square, with only half the quantity of metal, and, consequently, half the cost. Sufficient strength, however, may be still retained, and the weight of metal further reduced, by forming the bars with concave sides, as shown in section, by *Figs.* 3 and 4. The mode of making iron bars of a great variety of forms, we have already generally explained in our account of the iron manufacture. See IRON.

Fig. 1.

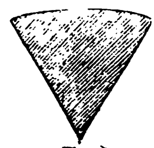


Fig. 2.

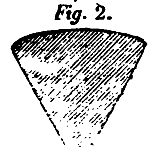


Fig. 3.

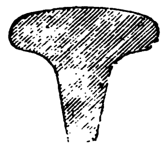
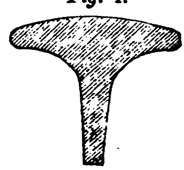
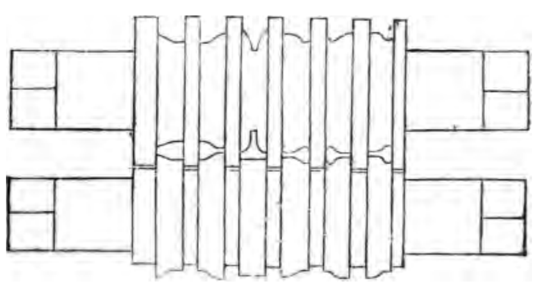


Fig. 4.



We shall therefore briefly describe here Mr. Birkinshaw's rollers, with reference to the following figure, which represents an elevation, or side view, of a pair of them. It will be observed, that the peripheries of each roller are indented with a series of grooves, like mouldings; each groove, except one in the upper roller, corresponding in form with another in the lower roller that is opposite to it; and that the figures represented by the hollow spaces left between the pair of rollers, are produced by the opposite surfaces being brought into contact. It will therefore be obvious, that when a red-hot bar of iron is applied to the grooves of such rollers, forced round by a powerful steam-engine with great velocity, the iron will be compressed into the same form throughout its length. The form of rail now most approved of, which we shall have occasion hereafter to describe, is made by the same kind of machinery just noticed. It may be deserving of



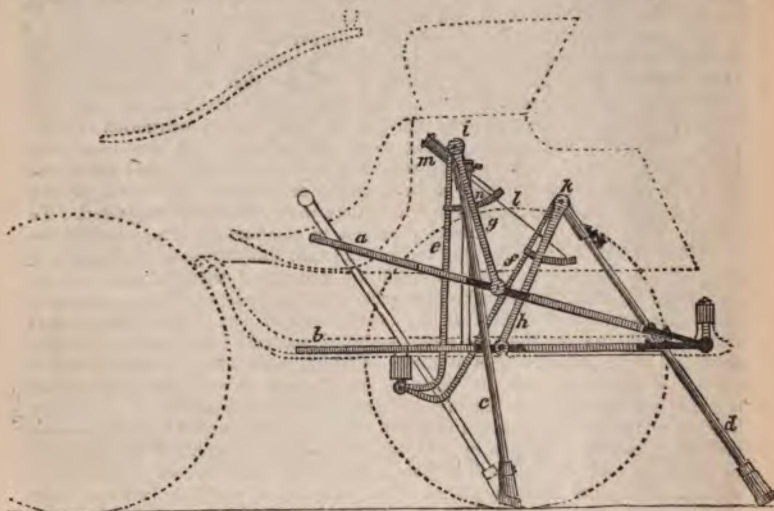
some of the members were led to believe, by the evidence of civil engineers, that all tubular boilers, or such as held their water in small distinct chambers, were modifications of "Gurney's principle." And the learned Dr. Lardner considered that the peculiar merit of the latter was the circumstance that every part of the boiler exposed to the action of the fire was filled with water. Those gentleman were of course unacquainted with the foregoing.

The great success which attended the improvements of the railway bars by Messrs. Losh and Stephenson, already described, seems to have stimulated rival manufacturers in the same undertaking; for we find that in the following year (1817) a patent was granted to Mr. John Hawks, of Gateshead, Durham, for "a new method of making iron rails, to be used in the construction of railways." The rails at that time in use, were, for the most part, cast iron; and those which were of malleable iron were merely square or flat rolled bars, and were, consequently, as liable to be bent, as the cast were to be broken, by the heavy weights and concussions to which they were continually subjected. To obviate those defects, Mr. Hawks proposed to combine the properties of the two different kinds of iron, so that the combination should possess the rigidity of the cast metal against dead pressure, and the tenacity of the wrought to tie the cast metal together, should it become broken by percussion. The specification states that—"Instead of making the rails or bars of cast or malleable iron, as those now in use are, they are a compound of malleable and cast-iron, so connected as to be stronger than if made of either kind alone. The surface is formed of cast iron, and the back, or under part, of malleable iron, joined together and formed when the metal of the former is in a fluid state; and they become so inseparable that the cast iron may be broken at the nearest possible distances; indeed, even inch by inch, which is scarcely possible to be occasioned by accident, and the rail will remain sufficient for the purposes of a railway; at least, till it suits the convenience of the workmen to replace it, without interruption to the concern in which the railway may be used: and as a loss by a broken rail of this invention will be less than one in common use, the expense, although it may be a little more in the first instance, will be considerably less in the end, as the malleable iron may be used again, or as the old iron will be of much more intrinsic value than the other."

The modes of combining cast and malleable iron together in the rails are various; but that which Mr. Hawks prefers, as affording the best security for their being firmly fixed together, is by running the cast iron, when in a state of fusion, on the malleable iron; to effect which the malleable part is to be first forged, or otherwise prepared in that form and of that strength which the nature of its intended purpose or appropriation points out as most proper. That part of the malleable iron which is intended to be combined with the cast iron should be rendered rough and uneven by jagging or by perforation, by giving it a dovetailed form, or by any other means, so that the cast iron may firmly adhere thereto, without the liability of becoming loose by the violent action of the carriages. The malleable part must be clean, perfectly dry and warm, when laid in the mould to receive the melted iron, which should be poured in as soon as possible after the mould is ready to receive it, as any damp on the malleable iron will endanger the soundness of the cast iron part.

The next subject in chronological order that is connected with locomotion is but little calculated to advance the general welfare; but there are some of our readers to whom it may prove sufficiently interesting and amusing. It is a very ingenious modification of Brunton's mechanical traveller, described at page 398, and is the subject of a patent granted to Mr. John Baynes, a cutler, of Sheffield, in September, 1819. The mechanism is designed to be attached to carriages for the purpose of giving them motion by means of manual labour, or by o suitable power. It consists of a peculiar combination of levers and represented in the following drawing, in which *a* and *b*, are tr moving upon joints, and having slips or openings about two-thirds of length, for the legs and rods to move in; *c* and *d* are legs or crutches, geer against the ground as fulcra, by which the carriage and *f* are rods which support the legs; *g* and *h* are dou

treadle is connected to its leg; the leg *c*, the supporting rod *e*, and the treadle-rods *g*, are joined together by a pivot at *i*; the leg *d*, the supporting-rod *f*, and the treadle-rods *h*, are joined together at the pivot *k*. The mode of operating is described as follows:—"Press upon the treadle *a*, when the rods *g* will bring



down the pivot *i* with the leg *c*, the rod *h* and the rod *g* into the situation represented in outline; the carriage being connected to the leg *c* by the rod *e*, will, by the action of the leg and rods, be impelled forward. At the same time, by pulling a cord *l* (which passes through a pulley-block *m*, and is connected at its two extremities to the rods, *e* and *f*, by the arms *n* and *o*) the leg *d*, the rod *f*, the rods *h*, and the pivot *k*, will be brought up to the situation of *c e g* and *i* respectively, ready for a stroke of the treadle *b*, which being then raised, will again impel the carriage." The patentee also states that "there may be several sets of the machinery above described for working each set with a treadle; or even only one set and one treadle; but I prefer two for ordinary purposes, particularly when only a single person is intended to be conveyed in the carriage, who may work the same by placing one foot on each treadle, in which the action will be alternate. The lower parts of the leg should be so formed or shod as not to slip upon the ground. This machinery may be variously applied to carriages, according to circumstances, so as that the treadles may be worked either behind or before the carriage, still producing a forward motion; in some cases it may be advantageous to joint the front end of the treadles to the carriage, and press the feet on the hind ends."

Our common roads, although constantly undergoing ameliorations, have not yet arrived at that degree of excellence to enable such machines as the foregoing to be worked by manual labour advantageously; but we look forward to the period when (owing to the spirit of emulation that will be excited by the success of the railway system) the resistance to the motion of wheeled carriages on the public highways will be reduced to half its present amount; which will render manual locomotive carriages, in many cases, not only practicable, but highly convenient and useful to their private owners. We would not, however, be understood as inferring that such motive force can ever come into successful competition with steam or even horse-power, as a means of *public* transport; or that such a machine as Mr. Baynes's is calculated to apply human strength [in t]he most favourable manner. Hereafter we shall have more to remark on [this] *subject*.

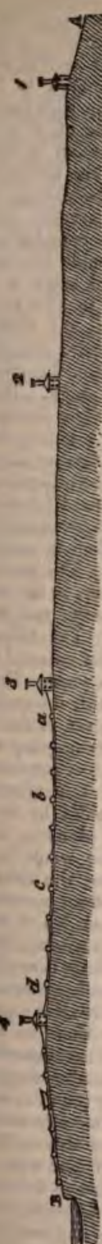
Although the invention of Mr. Hawks, described at page 409, was exceedingly ingenious, and the execution highly creditable to the mechanical skill of our "workers of iron," its success, as applicable to the construction of railways, was of short duration; for in October, 1820, the specification of Mr. John Birkinshaw, of the Bedlington Iron Works, in the county of Durham, was enrolled for a mode of constructing rails entirely of malleable iron, the process of which is so simple, and the result so excellent, as scarcely to leave any thing more perfect to be desired; all the bars of our present edge-railways are made by this process, and are but slightly modified in form. Previous to Mr. Birkinshaw's improvements, the edge-rails were chiefly of cast iron, resembling, for the most part, those described under Messrs. Losh and Stephenson's patent; and those which were formed of malleable bars were of the sectional shape, designated in the annexed figures in the margin, the first being technically called flat, and the second square bars.

Mr. Birkinshaw's attention was first drawn to the subject of substituting malleable for cast iron rails, by reading a Report made by Mr. Stevenson at that time, on the Edinburgh Railway. At page 26 of that Report, the author remarks, "One point, however, deserves particular notice here, as likely to be attended with the most important advantage to the railway system, which is the application of malleable iron instead of cast iron rails. Three miles and a half of this description of railway have been in use for about eight years on Lord Carlisle's works, at Tindal Fall, in Cumberland, where there are also two miles of cast iron rail; but the malleable iron road is found to answer better in every respect. Experiments with malleable iron rails have also been made at Mr. Taylor's Works, at Ayr, and Sir John Hope's, at Pinkie; and, upon the whole, this method, as in the case of the Tindal Fall Railway, is not only considerably cheaper in the first cost than the cast-iron railway, but is also much less liable to accident. In the use of malleable iron bars, the joints of the railway are conveniently obtained about twelve feet apart, and three pedestals are generally between each pair of joints." Previous to, and at the period of Mr. Birkinshaw's patent, a considerable degree of prejudice existed against the use of malleable iron rails, on account of their supposed liability to waste by rust. To settle this question by the test of experience, the agent of the earl of Carlisle, at Tindal Fall (where extensive lines of both kinds of rails were in use, as already mentioned) was applied to for information on the subject. In a letter dated May, 1819, to Mr. Birkinshaw, that gentleman said—"Our rails are one and a half inches square, and stand upon stones about ten inches square, and are placed at one yard distance from centre hole to centre hole. Our railway carries four tons weight, and has never cost us any thing yet, as to expense of the malleable iron, except creasing. *The iron I cannot see the least alteration with, although it has now been laid eight years.* The cast iron is a daily expense; it is breaking every day." The causes of the preservation of malleable iron bars, exposed to the weather, from rust, and their slow wear, may be readily supposed to be the constant friction to which they are subjected by the traffic, and to the condensation of the upper surface of the metal by the heavy weights rolled over it, which produces a hard compact coat, like that produced by cold-hammering steel and copper plates. The facilities which cast iron presents, of enabling the engineer readily to mould and run it into such forms as will combine the utmost strength with the least quantity of material (individually considered), made it, for a long time, a favourite; but the necessity of guarding against breakage, owing to the brittleness of the substance, occasioned them to be made so much heavier than the malleable, as to render the latter even of less first cost than the cast metal. It was from considerations of this nature that Mr. Birkinshaw was induced to attempt those improvements that are described in his specification; an extract from which we shall now make, it being particularly worthy of notice, as it is descriptive of the first and perfectly successful attempt to roll iron bars of those varied and useful forms, which so much abridge

middle of the road; the axles are made of wrought-iron, and where they run upon the upright bearings, about three quarters of an inch diameter. The plane is then made into a proper slope, between the platform or level upon which the wheel is placed, and the lower extremity, when a similar flat or piece of level road is made, for the descending train of waggons to land upon. The slope is either uniform, or such as the nature of the ground will permit. Sometimes it is necessary to make considerable bends or curves in the line of the road; but whatever be the form or length of the slope, it must always be terminated at each end by these flat platforms. The narrow parallel lines in the drawing, will show the rails as laid down upon the platform; the wheel being placed below the level of the rail, the square hole is covered up, and the rails pass over upon the cover. In the drawing, the rails are broken off at *k k*, the cover being removed to show the wheel. The dotted line A A, may be supposed to represent the one end of the platform, and the top of the plane. Three rails *r r r* are laid from this part nearly half way down the plane, of the requisite width between each rail, for the carriages to run upon, so that both the ascending and descending train pass upon the middle, and upon one of the outer rails; these are continued to where the one train of waggons have to pass each other. The three rails, then made to branch into four, in the same manner as A A to B B, for a certain distance, sufficient to allow the carriages to pass each other; these four rails then converge into two, or a single line of road, as shown at *c c*, and are so continued to the bottom of the plane, so that parallel lines, as shown in the drawing, will represent a complete passing. The empty, or ascending carriages will be at *c c* when the loaded carriages are at A A, and they will pass each other between K and B B'. In this form of plane, it will be seen, that the loaded carriages pass alternately down the sides D and E. For instance, if they commence their descent at D, one end of the rope being attached to them, and the other end being at E, at the foot of the plane, and fastened to the empty carriages, the loaded carriages will pass down D, and when they arrive at the bottom, the empty ones will arrive at the top, at E. Upon the other side of the plane, the loaded carriages, in the next operation, pass down the side E of the plane, and the empty ones up D. When used for passing boats from one level to another upon canals, and also on several railroads, a double line of road is laid from top to bottom of the plane, with a double line of rollers or sheeves; but the reader will perceive, that in most cases, the one above described will answer precisely the same purpose. In very short planes the obliquity of the road, in passing from a double to a single line, will cause a retardation to the carriages, and also additional friction to the rope; but upon long planes this is scarcely felt, and the cost of a double road the whole distance would be considerably greater.

When the slope of the plane is not uniform, descending more rapidly in some parts than in others, or when the descent is so great as to give more than a requisite preponderance to the moving power, a brake is applied to the periphery of the inclined wheel, to equalize or regulate the velocity of the carriages down the plane; and, in many instances, men traverse the plane with each train of waggons, and apply the brake or convoy of the carriages to check their velocity, when required. The brake upon the inclined wheel will be perceived to have no power in checking the velocity of the carriages more than what is equal to the hold the rope takes upon the wheel in passing round its semi-periphery; for if the excess of gravity of the loaded carriages, above what is required to overcome the whole retarding forces, be greater than the hold of the rope, the wheel may be completely stopped, and the rope slide round the wheel, which in some instances, might be attended with danger. The declivity of the plane should never be so great as to cause such an excess or preponderance of gravity, when such a wheel as this is used.

Many other plans have been suggested for employing gravity as a moving power. With a view of improving upon the various contrivances for surmounting the natural difficulties of a hilly country, Mr. Benjamin Thompson, late of ... *Durham*, took out a patent dated October 24, 1821, for "a method of ...*ing the conveyance* of carriages along iron and wood railways, tramways,



and other roads;" in the specification of which, he states, that it consists in the application or use of two, or more, fixed engines, placed upon the railway, or other road to be used, at such a distance from each other as the nature of the line chosen shall render most convenient, and in such a manner as that the action of such engines shall be *interchangeable and reciprocal.* Mr. Thompson says, that " whether the line of road rises or falls, much or little, is level or undulating, matters not; the carriages, loaden and empty, are made to pass in both directions with a uniformity of progress, and at the same time with a despatch not heretofore known. A road on which my invention is about to be applied, must be divided into stages, attention being given, in determining their distances, to the nature of the line, in regard to curves or bends, and to the undulation of the surface. The nearer it approaches to a level, and the fewer, as also the easier, the bends are, the better will it allow of the stages being extended. On the other hand, should the line prove to be a very uneven one, with frequent and short bends, then the intervals or spaces between stage and stage will necessarily be required to be shortened accordingly. I shall probably be able more clearly to explain my method by describing a supposed case. Let the supposed road, to which my invention is to be applied, be a railway (either already in being, or to be made,) from a colliery to a staith, seven and a quarter miles in length. A proper survey being taken, and a plan and section of the line made, I find it to be expedient to divide it into five stages, in the manner shown by the drawing annexed. The first stage of the colliery may be formed to a tolerably uniform ascent, by the aids of cuts and batteries, of one and half inch to the yard, being three-quarters of a mile in length, and terminating at a summit, on which is to be erected a steam-engine, of power sufficient to draw up the plane six loaden coal waggons at once, containing a Newcastle chaldron each, at the rate of seven and a half feet per second. This stage is a regular inclined plane, and is to be wrought according to the first of the modes already described as now in use; for the returning empty waggons will pass downward by their own gravity, and take the rope with them, preparatory to the drawing up of another loaden set. The full set being drawn up in eight minutes and forty-eight seconds, the empty set allowed to pass down in seven minutes and eighteen seconds, and three minutes occupied in the changes at the ends, will cause one operation of the plane to be completed in nineteen minutes and six seconds. The engine which I call No. 1 is the first station. The second stage lies over a variable or undulating surface, the two extremities of which are distant one mile and three-quarters, and stand nearly level with each other, the intermediate country not admitting, but at too great a cost, of the line being rendered level; the ascents and declivities are moderate, neither exceeding one inch in the yard; and the curves or bends are easy, and not numerous. A steam-engine, No. 2, is erected at the farther termination, which is the second station, to be used for

drawing twelve loaden waggons along this stage at once at the rate of eight and three-quarters feet per second, and bringing along with them a rope from No. 1 engine, which is allowed to run off a wheel, not connected with No. 1 engine, during their passage to No. 2 engine; upon their arrival at which, twelve empty waggons are substituted, which are drawn back to No. 1 by the reconnexion of the rope-wheel with that engine, bringing with them a rope from No. 2 engine, which is, in like manner, suffered to run off a wheel then thrown out of connexion with No. 2 engine. The operation of this stage, both from and towards the colliery, is thus carried on by the alternate action of Nos. 1 and 2 engines, standing at its extremities. The passage of a set of waggons takes up seventeen minutes and thirty-six seconds each way, and the changes three minutes; making together, for a completion of the operation, thirty-eight minutes and twelve seconds, or double the time taken by a set of half the number on the first stage. The third stage is also one mile and three-quarters long, and very similar in regard to plan and section to the second stage. A steam-engine, No. 3, is placed at the third station, which is the furthest extremity of the stage, to draw the loaden waggons along the same; and the empty ones are to be taken back by No. 2 engine, in the manner which has just been described on the second stage. The speed, and the number of waggons to a set, are the same also. The fourth stage is more favourable than the second and third, extending over a gently undulating country, and being nearly straight; the fourth station, or further extremity of the stage, being, in point of level, twenty feet higher than the other end of it. A steam-engine, No. 4, is to stand at the fourth station, to be used for drawing the waggons from the third station. Nos. 3 and 4 engines will thus alternately act to each other on this stage, as Nos. 1 and 2 have been described to reciprocate on the second stage, and also Nos. 2 and 3 on the third stage. The length of this stage is two miles; and twelve waggons are to travel together, at the rate of ten feet per second, which will complete the process of a passage each way, with the changes, in thirty-eight minutes and twelve seconds. The fifth and last stage, which is one mile long, declines regularly by the help of cuts and batteries, to the staith, averaging three-quarters of an inch to the yard. The loaden waggons are made to pass down the same, in connexion with the machinery of No. 4 engine, and also during the time of its drawing a set of full waggons along the fourth stage; the waggons along the fifth stage moving with half the velocity of the waggons along the fourth stage, or five feet per second, and consequently performing the journey in the same time. The advantages of this cooperative movement are, that No. 4 engine, being aided by the gravity of the twelve loaden waggons passing down the inclined plane to the staith, requires only about one half the power which otherwise would have been necessary for drawing independently the full waggons from the third station, and the descending waggons themselves are restrained from proceeding too rapidly, and their speed accurately regulated. The engine No. 4 is used to draw the empty waggons back again from the staith. This mode, whereby the gravity of the loaden waggons passing down an inclined plane is applied in aid of an engine for drawing loaden waggons forward upon another stage, is quite new, and has never been used before; but I do not claim it as any part of my said invention. The second, third, and fourth stages, are those on which my method is applied. Nos. 1 and 2 engines reciprocate, or act interchangeably with each other on the second stage; No. 2 drawing the loaden waggons from the first to the second station, and No. 1 pulling the empty (or in case of need, loaden) waggons back again. Engines Nos. 2 and 3 operate alternately in the same manner with each other upon the third stage; and so also do Nos. 3 and 4 on the fourth stage. The engines are severally to be furnished with two rope-wheels, and a rope to each, of a length and strength suitable to the stage upon which they are to be used. The rope-wheels must be so constructed as to allow of a ready connexion, or the contrary, with their respective engines, so as to be capable of being acted upon by them, or of turning round, independently, at the will of the engine man. This may be readily accomplished by any one of the modes in use with mill-wrights for throwing machinery into or out of gear, with

a moving power, and does not require to be here described. I make use of very light friction-wheels, *a b c d*, &c. in the drawing, placed vertically, at proper intervals, to bear the ropes from the ground, where the road is straight; and round the curves or bends I place similar wheels, in inclined positions, for the same purpose. Although two miles have been mentioned as the longest of the stages upon the supposed road, it is practicable, under the circumstances of a favourable country, to extend the operation to much longer stages. Without the application of my invention to the supposed road, of which a detailed account has been given, horses would be required to draw the waggons upon the second and third stages, because the ascent of one inch to the yard is too great for locomotive engines to be used upon them, independent of the question as to their effecting a saving at all upon horse labour, on those level roads where they are applicable. Upon the fourth, or two mile stage, they might be adopted; but, from the doubt as to an advantage under any circumstances arising by their use, horses would most likely be deemed the more eligible for working it also. Compared with horse labour, my method would, upon those three stages, effect, in all probability, a saving of seventy-five per cent. In cases of greater inequality of surface, the saving would be in a still greater ratio. A further and very important reduction in the cost of a new road, would result from its adoption. In the formation of a road, it is generally necessary to make deep cuts, and raise high batteries, in order to obtain a uniformly rising, falling, or level surface; and it frequently happens, too, that the direct line of way must be materially diverged from, to favour that purpose. My plan dispenses with such nice attention to regularity, the engines being capable of surmounting acclivities, and the wheels which give out the following or passive rope, affording the means of restraining the too rapid progress of a waggon down a declivity. In short, there is no country, however uneven or variable its surface, but that may, by my method, be traversed. For conveying minerals underground, where the unevenness of the strata and their general disposition to undulation do not allow of a uniformly ascending, descending, or level road, my invention is peculiarly applicable. Briefly, then, and it will easily be collected from what has been said, 'My method of facilitating the conveyance of carriages along iron and wood railways, tramways, and other roads,' is the reciprocal action of two engines, standing at the extremities of a stage, or portion of road to be travelled over, one engine drawing the carriages forward in a direction towards itself, and along with them a rope from the other engine; which rope, in its turn, pulls the same or other waggons, by means of the other engine, back again, and also a rope therewith—thus, by the alternately active and passive agency of two ropes, are the powers of fixed engines made to act in opposite directions, thereby causing a road to be traversed both ways, by loaden or empty carriages, at any desired speed. It is the reciprocal and interchangeable application of power, as hath been described, which I claim to be my invention."

The inventor had an opportunity of putting his plan into execution, immediately after the sealing of his patent, at Ouston colliery, in the county of Durham, and about seven miles from Newcastle, upon a length of line of seven and a quarter miles, as in the supposed case mentioned in the specification. The principle was, however, at that time only applied through the medium of two steam-engines, previously used in drawing loaden waggons up inclined planes.

The distance of the two engines from each other was 2315 yards, the upper end whereof is a steep inclined plane, 323 yards long, up which the carriages were drawn by the Ayton engine; and the remaining portion, which is 1992 yards, which had previously been worked by ten powerful horses, the ascent of it being 65½ feet, but not a regular acclivity. The engine at the lower end was for the purpose of drawing loaden waggons up an inclined plane extending 387 yards in the contrary direction, or towards the colliery. The two engines, in addition to their former work, have been made to reciprocate with each other over the whole length of the horse road (which has considerable curves and irregularities) according to the mode described in the foregoing specification upon the second, third, and fourth stages.

Six loaden waggons, coupled together, carrying the same number of Newcastle chaldrons, or 15 tons 18 cwt. of coals, pass upward at a speed of 10½ feet per second, or 7 miles an hour, with the greatest ease and certainty, affording a despatch by no means derived previously from the use of animal power. The two extremities being visible to each other, are furnished with flags, to give alternate signals of the readiness of the waggons to proceed. When the atmosphere is hazy, and the flags cannot be seen, signals are made by drawing forward the rope three or four yards with the engine, at that end which the waggons are intended to go, and which is instantly perceived at the other end. And in the dark, (for the work is daily prosecuted during five or six hours' absence of light during this period of the year,) signals are given by a fire kept up at each end for lighting the workmen, which is shut from, or opened to, the view of the opposite extremity by means of a door. A person accompanies the waggons constantly, seated in a chair fixed securely upon the fore end of one of the soles of the leading waggon of the set, which is easily removed from one to another. The use of such attendant is to disengage the hauling rope from the waggons by means of a spring catch, in the event of any sudden emergency, such as the breaking of a wheel or rail, or the hazard of running down any object, the stage in question lying over a common. Friction wheels of cast-iron, weighing 14 lbs. each, having an axis of malleable iron, turned in a lathe, and weighing 1 lb. and running upon a frame of oak, are placed eight yards asunder, on the straight parts of the way, and five yards from each other along the curves. For the latter purpose they are put into frames of iron and wood, which allow of an inclined position to any angle. The requisite inclination of the wheel, or that which is best suited to the curvature of the road, is soon found out by the road-wrights. The greatest deviation from a vertical line found necessary in the present case, was 45 degrees. The angle properly adapting the leaning friction-wheel, is that which allows of neither an upward or downward stress of the rope, but which presents the wheel in such a manner as that the strain of the rope shall be in a line at right angles with the axis. The friction-wheels are 11 inches diameter, with a groove 2½ inches deep, opening from a narrow bottom to 4½ inches at the top. The inclining wheels have a cast-iron horn projecting 5 inches from the frame at its under side, to receive and guide the rope into the groove. The wheels are all made to run upon oak bearings, and are greased once every day; they act well, and run in the lightest possible manner, occasioning a friction incredibly small when their number, (350,) and the length and weight of ropes, are considered; for in order to preserve and keep safe the ropes, they are both housed every night, the last set of loaden waggons being drawn up without the tail or passive rope, and in the morning *that* rope being first conveyed upwards with a single empty waggon by a horse, which performs the task without difficulty at the common working pace of 2½ miles per hour.

In the fourth volume of the *Transactions of the Highland Society*, are some very interesting papers by Mr. Scott, of Ormiston, which are descriptive of several ingenious methods of overcoming ascents on railroads by means of animal power; they are, for the most part, unsuited to the scale of operations contemplated in the great lines of public railroad now forming in all parts of the kingdom; but in branch communications from one line to another, and for facilitating the traffic and intercourse of adjacent towns and villages with the main lines, as well as the formation of private railroads, where economy of construction is of primary importance, some of the suggestions of Mr. Scott appear to be deserving of attentive consideration. Under these impressions we shall make a few extracts from those papers, for the information of our readers.

In the first plan which we shall notice, waggons or carriages of any kind, as also boats on carriages, having wheels to correspond with the breadth of the railways, will continue as horizontal in passing up and down inclined planes, even of 45° of elevation, as if travelling upon a level railway. The first idea of this, was to construct waggons on purpose for ascending and descending upon these steep inclined planes; but an improvement was afterwards thought of, by

which carriages of almost every description may pass up and down these inclined planes, provided that their wheels be fitted to the railways.

All public lines of railway will require two distinct sets of railway tracks, and, consequently, the inclined planes upon it must be fitted up with machinery that will take up carriages upon the ascending plane, either empty or loaded, at the same time that empty or loaded carriages are passing down the descending plane; and, in like manner, let down on the descending plane either empty or loaded carriages, when there are neither empty nor loaded carriages to pass up the ascending plane: all such properties are requisite for general service on a public line of railway. Inclined planes that have upon them ascending and descending tracks, are called double inclined planes; but those about to be described may be called double-railed inclined planes, as both the ascending and descending planes have two sets of rails.

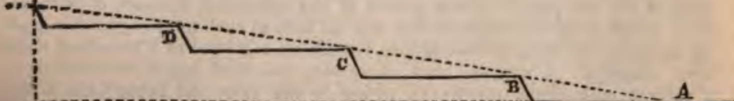
The first step to be taken towards the formation of these inclined planes, is to commence at the foot of the acclivities that are proposed to be ascended and descended, and to cut forward a level roadway of a necessary breadth for a double railway, not having less than four feet in breadth between the two railways, until a perpendicular height is gained of from eight to ten feet. This face is not to be left perpendicular, as in the last proposed method, but is to be sloped away towards the rise of the acclivity with an uniform regular shape, until it forms an angle of 45° with the horizon, or an outward angle of 135° with the level line of the railway. At the top of this inclined plane we again commence and cut forward a similar roadway, until the face of the cut be such as will admit being formed into another inclined plane, like to the first; and, in like manner, continue to cut forward roadways and form inclined planes, all the way to the top of the acclivity, or else to a height where it may be judged proper to strike off with a level railway. All these steep slopes are to be carefully flagged with well-dressed durable stones, laid in lime; and the sides of the roadways are to be properly built with a face-building, until it reach near to the foot of the paved slopes. Strong walls are also to be built on each side of the slopes with large hewn stones: the tops of these walls are to be carried up parallel with the slope of the pavement; and the height of each of these walls, measuring at right angles with the pavement, may be three feet; and they are to be carried up to a level with the upper roadway. A middle wall of strong mason-work, of four feet in thickness, is to be built exactly up the middle of the paved slopes, corresponding precisely as to height and slope with the side walls, and which are also to be carried to a level with the upper roadway.

Matters being thus far arranged, the next step is to lay all the level roadways with rails, so as to form railways of about four feet three inches between the tracks. Rails are not only to be laid along level roadways, but they are also to be laid up along the inclined paved planes, in a secure and substantial manner. There is, likewise, a rail to be laid upon the top of each of the side walls of the inclined planes, in a parallel manner to those upon the pavement, and which are to be securely fixed within three inches of the face of the walls. The length of a horizontal line between the rails that are upon the pavement, and those that are upon the top of the side walls, will be found to be (at the height that these walls are proposed to be built) four feet three inches, nearly. Now, if a carriage be made with two pair of wheels, all of the same diameter, having its fore-wheels to correspond with the railway-tracks that are upon the pavement, and its hind-wheels with a longer axis, to correspond with the distance between the rail-tracks that are fixed upon the top of the side walls, and the axles of the two pair of wheels placed at the calculated distance of four feet three inches from each other,—then will the body of such a carriage, when passing up and down these inclined planes, remain equally level as if travelling along level railways. A carriage, such as we have described, could not travel along a railway with single rail-tracks, owing to the axles not being both of one length; and to have a railway on each side, would be attended with much additional expense; or to have small rollers on projecting ends of the hind-axles, would give the carriage an awkward appearance; therefore, the following method is proposed *which is, to* sink a place at the foot of the inclined planes,

of a length, breadth, and depth fit to receive a platform carriage with four wheels, its fore ones to fit the rail-tracks on the pavement, and its hind wheels to fit the tracks that are on the top of the side walls. Upon this carriage two rails are to be fixed, to correspond exactly upon the level railways, and to butt against them. A stayed iron draught-bar is to be strongly fixed to each side of this carriage, to fasten the ropes to, by which the machinery is employed to raise up or let down the carriages. The position of the draught-bars will be regulated by the centre of gravity of the weight that is to be brought up. From this arrangement it will appear, that a waggon, such as we have placed upon it, or any cart or carriage whatever, that has wheels corresponding with the railway, will readily enter upon these platform carriages, which may easily be prevented from running off, while ascending or descending upon the platform, by means of a piece of chain fixed near to its fore end. As these platform carriages are only intended to pass alternately up and down the inclined planes for carrying the railway carriages, it is requisite that, on reaching the top or bottom, the rails shall also correspond, that the waggons may leave the platform on the chain being unhooked that is to prevent them from running prematurely off. An experiment was made upon a railway having a declivity of twelve and a half inches in 100 feet of length, with a loaded coal-waggon, whose weight, including the carriage, was two tons. A middle-sized old man pushed this waggon down the declivity, and gave it a considerable motion; the waggon was stopped when the same old man set his back against it, and brought it up to the above-mentioned acclivity, without much apparent difficulty. This is stated to show, that where the distance between the inclined planes is short, the carriages may be pushed along by one man upon a level railway; or he might be put in possession of a kind of acceleration to be wrought by treadles, by which he could employ both his weight and his strength by laying hold of two handles to give greater power to his feet. Or, in place of cutting forward a level roadway to the ascending plane, it may be cut with an easy declivity, and the railway to the descending plane with a gentle acclivity, by which the carriages, on being put in motion by hand, would run of themselves to the inclined planes. By forming the roadways in this manner, the ascending plane would become somewhat more, and the descending plane somewhat less, in height, than they would have been had the roadways been level; but as it may be best to have both inclined planes of the same length, it will only be necessary to make the descending plane with a longer slope; for although 45° is here mentioned, there is no necessity for adhering to that angle. Where the distance between them is great, the level railway, and a horse to be employed to pull the carriages between them, is to be preferred. Although it is practicable to make inclined planes, upon the same principle as those described, to take up more than one waggon at a time, yet the power that would be required, and the several disadvantages that would attend it, are such as will much more than counterbalance any advantage or gain to be made; for which reason there need be no hesitation in recommending the taking up or letting down only single waggons at a time; and possibly it may be found that the most beneficial and eligible weight to be carried will not exceed two tons, including the weight of the carriage.

The mechanical power of an inclined plane, having 45° of elevation, reduces the weight of two tons to that of 28.284 cwt.; to which is to be added for

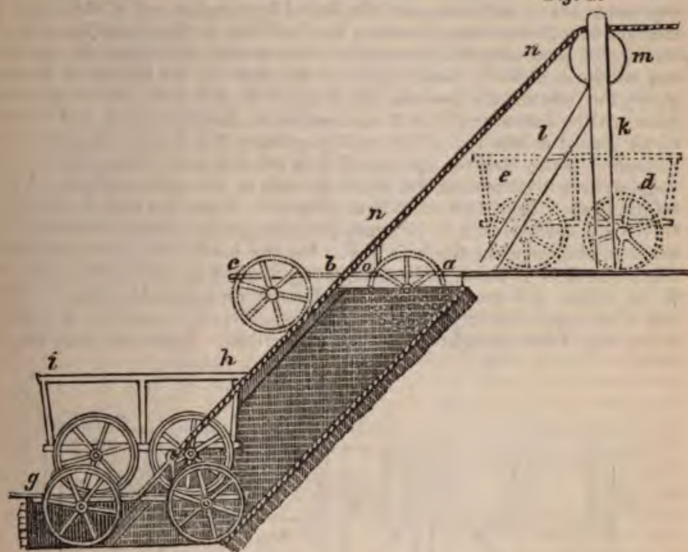
Fig. 1.



ion, the power required to move it along a horizontal plane. The above *1, shows* an acclivity cut into four inclined planes B C D and E, in the

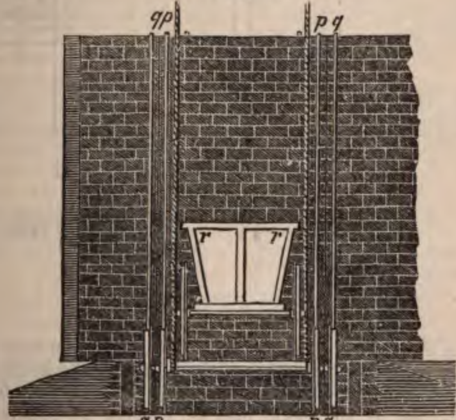
manner proposed; the dotted line A E represents the original line of the surface, and the line E F the perpendicular height gained by the four inclined planes. A B C D in *Fig.* 2, is a section of one of these inclined planes, showing

Fig. 2.



one of the side walls built with hewn stones; the dotted figure *a b c*, one of the platform carriages at the top F G of the inclined plane, where the waggon *d e* in dotted lines, has entered upon it; *f g* is another platform carriage at the

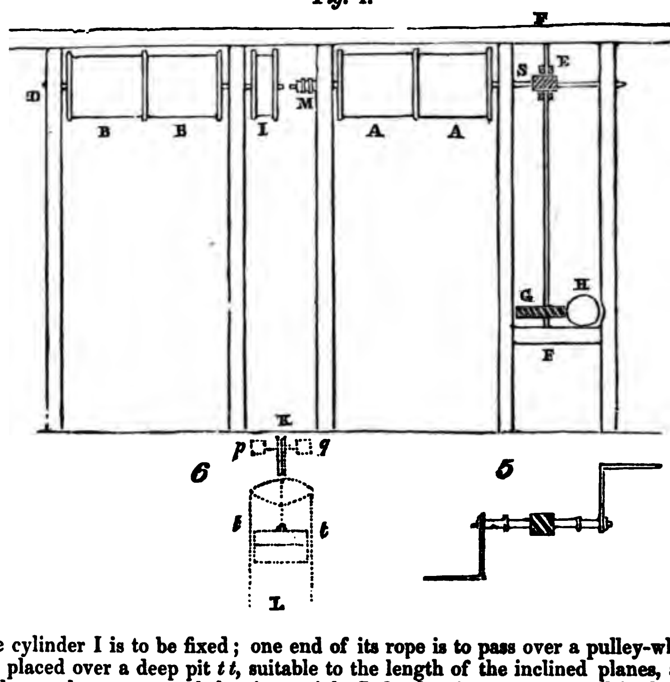
Fig. 3.



bottom of the plane, with a waggon *h i* upon it, the fore-wheels of which are fixed with a piece of chain to prevent its running off the platform-carriage

when in the act of ascending or descending. The wheels of this waggon are upon a level with the lower line of railway H I. The wheels of the platform-carriage are represented as travelling upon the pavement K L, and upon the top of the side walls M N; while *k l* represents a side view of part of the frame-work of the coiling cylinders, and *m* an end view of one of the cylinders; *n n* represents one of the ropes, and the dotted figure at *o* one of the stayed iron draught-bars for fastening the ropes by which the carriages are drawn up or let down. The preceding *Fig.* 3 is partly a cross section, but chiefly an elevation of one of these inclined planes; *p p p p*, the rails in the bottom of the plane; *q q q q* the rails that are upon the top of one of the side walls, and *r r* the waggon upon it. The following *Fig.* 4 is an elevation of the frame-work and machinery to be placed at the top. The coiling cylinder A A is to be placed to suit the ascending plane, and the cylinder B B to suit the descending plane. At M a coupling-box is introduced, by which the axis of the coiling-cylinder A A can be disengaged from that of B B at pleasure. Upon the axis of the cylinders C D a screw-wheel E is to be fixed, and wrought by a double-threaded endless screw S, that is upon the axis F F. On the lower end of this axis another screw-wheel G is fixed, to be wrought by another two-threaded endless screw H, on whose axis are two winch-handles, as represented in *Fig.* 5. The one end of the ropes that are upon the coiling cylinders A A and B, is to be fastened to the stayed iron draught-bars, already described. Upon the same axis, C D,

Fig. 4.



the cylinder I is to be fixed; one end of its rope is to pass over a pulley-wheel K, placed over a deep pit *t t*, suitable to the length of the inclined planes, and to have a heavy counterbalancing weight L fixed to it, as represented in dotted lines in *Fig.* 6. At M the same may be effected by means of wheel and pinion apparatus.

In situations where a stream of water can be brought forward to the top of a *single inclined* plane, an oblong pit may be sunk of a depth answerable to the length of the inclined plane, and a level mine cut to its bottom, to free it of water.

Over this pit is to be placed a long coiling cylinder, having a range of buckets suspended from it by ropes; the buckets are to have valves to open upwards, when necessary, by means of small cords. The ropes that are to pull up the waggons are to pass over pulley-wheels placed in a proper position, and at a proper height, the one end of the ropes being fixed to the waggons, and the other end to the pit cylinder. The weight of water that each bucket holds being known, will enable the engine man to know what number to fill for the weight of the waggon to be drawn up; on the necessary number being filled, they will then descend, and pull up the waggon: a brake-wheel is to be fixed on the axis of the pit-cylinder to regulate its motion. When the buckets are at the bottom of the pit, should it be required to let down a loaded waggon, the counter-weight is to be adjusted to the weight to be let down, by pulling a necessary number of the valve-cords, to permit the water to escape from the requisite number of buckets; the ascent of the buckets and descent of the waggon to be regulated as before, by the brake-wheel. Should all the buckets be at the bottom of the pit, at a time when they are wanted to pull up another waggon, the ropes of all the valves are to be pulled, that the buckets may be all emptied; and for this purpose there is to be, besides the range of buckets already mentioned, a large bucket, with a valve in its bottom, that opens on reaching the bottom of the pit, having its rope coiled the contrary way round the pit-cylinder, to that of the range of buckets; this bucket is to be so suspended from the pit-cylinder, that, when all the other buckets are at the bottom of the pit, this shall be at the top. By filling this large bucket with water when at the top of the pit, it will descend, and occasion all the empty ones to ascend to the same place; and, when refilled, they will again be in readiness to pull up another waggon. By thus having a range of buckets, the counter-weight can be so regulated as to answer the weight of different carriages, whether loaded or unloaded. It is unnecessary to point out the simple manner in which the water can be directed into the different buckets, and stopped when not wanted. The perpendicular height of canal-locks is very generally about eight feet. This appears also to be a suitable height, for the greater that the height is the greater will be the disproportion of cutting and mason work, between a high and low inclined plane; for, by calculation, it will be found, that, in the formation, one of sixteen feet high will contain four times the number of cubic yards of solid cutting compared with one of eight feet, and require four times more face buildings, and these of much greater strength. At these short inclined planes the whole ropes and machinery may be roofed in, and kept dry in all kinds of weather; and, under the same roof, the engine-man and his boy may have a cabin. It is with a view to reduce the number of horses kept, that these short inclined planes are so much recommended, as also to find employment for industrious labourers."

Mr. Thompson's plan of working inclined planes by fixed engines, has, we understand, been very successfully carried into effect in many places; and so have some of Mr. Scott's propositions, in a modified form. We must now, however, leave this part of the subject, to introduce to the reader an entirely different description of railway conveyance, invented by Mr. H. R. Palmer, at present the engineer to the London Dock Company, and which was patented by him on the 22d of November, 1821. Instead of two lines of rail laid upon the ground, as heretofore, Mr. Palmer's railway consists of only one, which is elevated upon pillars, and carried in a straight line across the country, however undulating and rugged, over hills, valleys, brooks, and rivers, the pillars being longer or shorter, to suit the height of the rail above the surface of the ground, so as to preserve the line of the rail *always straight*, whether the plane be horizontal or inclined. The waggons, or receptacles for the goods, travel in pairs, one of a pair being suspended on one side of the rail, and the other on the opposite side, like panniers from the back of a horse. By this arrangement only two wheels are employed, instead of eight, to convey a pair of waggons; these two wheels are placed one before the other on the rail, and the axle-trees upon which they revolve are made of sufficient length and strength to form extended arms of support, to which are suspended the waggons

WEIGHT OF AXLE AND LEAD, 2465 POUNDS. BEARING 4½ INCHES.					
Axle well oiled in the Four First Experiments.			Axle well oiled in the following Experiment.		
Number of Experiments.	Vibration of Pendulum.	Number of Revolutions.	Number of Experiments.	Vibration of Pendulum.	Number of Revolutions.
274	505	238	301	551	265
275	549	258	Oil remov	ed from top	of chair.
276	537	253	302	454	206
277	540	252	303	357	160
Oil removed	from top of	chair.	304	315	140
278	400	189	305	281	122
279	332	152	306	242	113
280	290	130	307	257	110
281	264	116	308	230	98
282	249	106	309	228	95
283	244	103	310	213	92
284	235	98	311	203	87
285	226	95	312	196	84
286	222	93	313	191	81
287	206	88	314	180	76
288	206	84	315	172	71
289	199	81	316	164	67
290	188	79	317	153	65
291	181	75	318	134	58
292	168	70	319	123	54
293	158	66	320	113	58
294	150	63	321	99	43
295	131	56	322	85	38
296	114	47	323	81	36
297	108	44	Axle well	oiled in the	two follow-
298	94	39	ing	experiments.	
299	91	38	324	580	278
300	89	37	325	596	270

In conducting these experiments, the first four were made with the axle oiled, so as to keep it constantly feeding on, as shown in the figure. The weight being drawn up was liberated, and falling 30 feet, the respective number of revolutions were made before the axle came to a state of rest; the second column being the time in oscillations of a pendulum vibrating 300 times in 157 seconds. At the end of experiment 257, the oil which was resting upon the bearing, heaped up, as shown in the figure, was merely removed, as cautiously as possible, so as to allow that which surrounded the axle to remain; the weight was drawn up as before, and falling precisely the same distance, the number of revolutions was, in that experiment, 189. No additional oil being applied, the weight was successively drawn up and liberated as before, and the number of revolutions were found, as shown in the table, until the end of the 300th experiment, when the number of revolutions, by the same moving force, was only 37; during the whole of which period the axle was never touched, no oil was applied, and none removed. At the end of the 300th experiment, the axle was again copiously oiled, so as to feed on during the whole of the 301st experiment, when the number of revolutions were 265. The oil was then removed as before, when the number regularly diminished until the 323d experiment, when it was again reduced to 36; and when, in the next experiment, the oil

openings, to receive the rail B, which is composed of deal planks, set on their edges, with their upper surface C defended by cast or wrought-iron plates, a little convex on the upper side. When the rail has been some time in use, and all has taken a bearing, a little adjustment of the line may be requisite before the rail is bolted to the pillars; to effect which, a very simple and easy method is provided. In the cleft of the pillars, and under the rail, two wedges *a a* are introduced in opposite directions, whereby its level may be adjusted with the nicest accuracy. The wheels D D are provided with flanges, to keep them on the rail, and their peripheries are slightly concave, to adapt their surfaces to that of the rails. E E are the arms or axles; H H are the receptacles for the goods, which are made of plate iron, and are suspended to the arms, as before mentioned, by the inflexible rods I I I I. To one of the arms a chain K is hooked, to which a towing-rope may be connected. Any number of carriages may then be attached together by chains hooked on to the angles.

The annexed *Fig.* 4 is intended to exhibit a portion of the railway in use, and the methods by which several of the obstacles which frequently present themselves are overcome. On the left is seen a jointed rail, or gate, that crosses

Fig. 4.

the road over which the carriages have just passed, and the gate swung back, to leave the road open; the horse and man having just forded, the train of carriages is proceeding in its course, and following another train, part of which is seen on the right, crossing a rail bridge, simply constructed for that purpose.

Provision is made for trains of carriages that are proceeding in opposite directions, by means of "sidings" or passing places. With respect to loading, if both receptacles be not loaded at the same time, that which is loaded first must be supported until the second is full. Where there is a permanent loading-place, the carriage is brought over a step or block; but when it is loaded promiscuously, it is provided with a support connected to it, which is turned up when not in use. From the small height of the carriage, the loading of those articles usually done by hand becomes less laborious. The unloading may be done in various ways, according to the substance to be discharged, the receptacles being made to open either at the bottom, the ends, or the sides. In some cases it may be desirable to suspend them by their ends, when, turning on their own centres, they are easily discharged sideways.

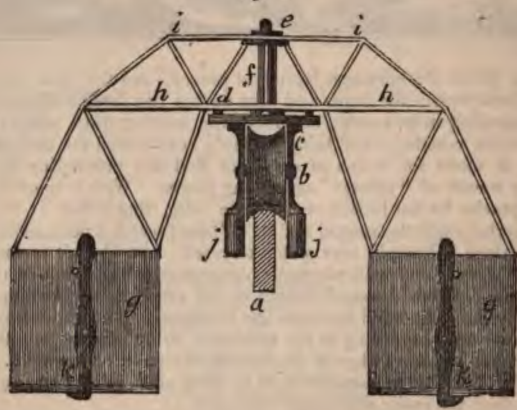
Among the advantages contemplated by the patentee of this railway, may be mentioned that of enabling the engineer, in most cases, to construct a railway on that plane which is most effectual, and where the shape of the country would occasion too great an *expenditure* on former plans—that of being maintaineded

a perfectly straight line, and in the facility with which it may always be adjusted; in being unencumbered with extraneous substances lying upon it; in receiving no interruption from snow, as the little that may lodge on the rail is cleared off by merely fixing a brush before the first carriage in the train; in the facility with which the loads may be transferred from the railway on to the carriages, by merely unhooking the receptacles, without displacing the goods, or from other carriages to the railway, by the reverse operation; in the preservation of the articles conveyed from being fractured, owing to the more uniform gliding motion of the carriages; in occupying less land than any other railway; in requiring no levelling or road-making; in adapting itself to all situations, as it may be constructed on the side of any public road, on the waste and irregular margins, on the beach or shingles of the sea-shore,—indeed, where no other road can be made; in the original cost being much less, and the impediments and great expense occasioned by repairs in the ordinary mode, being by this method almost avoided.

A line of railway on this principle was erected, in 1825, at Cheshunt, in Hertfordshire, chiefly for conveying bricks from that town, across the marshes, for shipment in the river Lea. The posts which support the rails are about ten feet apart, and vary in their height from two to five feet, according to the undulations of the surface, and so as to preserve a continuous horizontal line to the rail. The posts were made of sound pieces of old oak, ship timber, and in *a*, the slot or cleft at the upper ends of the posts, are fixed deal planks twelve inches by three, set in edgeways, and covering with a thin bar of iron, about four inches wide, flat on its under side, and very slightly rounded on its upper side; the true plane of the rail being regulated or preserved by the action of counter-wedges between the bottom of the mortices, and that of the planks. By this rail, on the level, one horse seemed to be capable of drawing at the usual pace about fourteen tons, including the carriages.

The late Mr. Tredgold, whose opinion in matters of this nature will ever be entitled to attentive consideration, expressed himself very favourably to this invention in his *Treatise on Railroads and Carriages*: — "We expect (he observes) that this single railroad will be found far superior to any other for the conveyance of the mails and those light carriages of which speed is the principal object; because we are satisfied that a road for such carriages must be

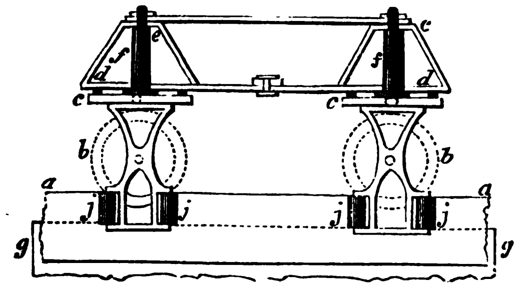
Fig. 1.



raised so as to be free from the interruptions and crossings of an ordinary rail way." It has generally been considered a defect in Mr. Palmer's arrangement, *that in order to make* turns in the road, it is necessary that a portion of the rail

should be made to turn with the carriages upon it. This defect, Mr. T. Chapman, of Royal-row, Lambeth, proposed to remedy, by so constructing the carriage, as to enable it to turn itself upon a fixed suspension rail, whether curved or straight, or from one angle to another. *Fig.* 1 on the preceding page exhibits an end view of the carriage, and *Fig.* 2 a side view of the same, partly

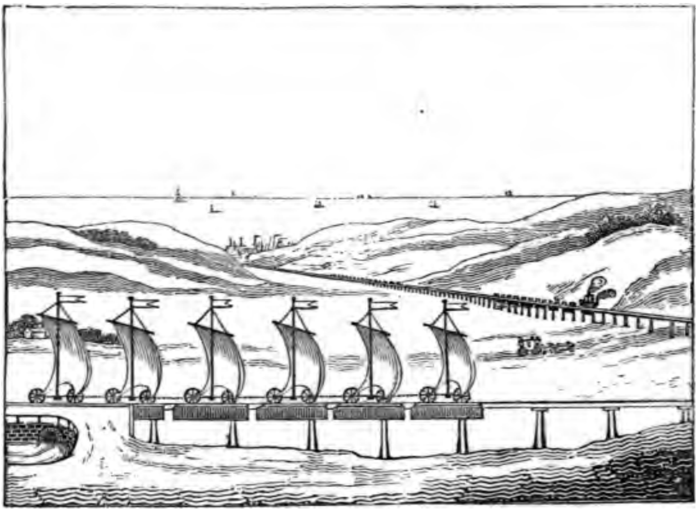
Fig. 2.



in section. *a a* is the rail, *b b* two wheels on the rail; these carry the turning plates *c c*, each having four friction-rollers: *e e*, upper plates; *f f*, the vertical axis of the wheel-frames or turn-plates *c c;* they pass through the plates *d* and *e*, from which the boxes *g g* are suspended, by the lateral arms *h h* and *i i*. Now as the wheels and frames *b c* can turn freely on their axis *f f*, they each require four guiding rollers *j j j j* to keep them in a right line with the rail, and to cause them to turn as the rail turns. These carriages should not be further asunder than is absolutely necessary for the required curve of the rail. The bottom of the carriage has a joint at one third of its length, and is held up at this by the hooks *k k;* by removing these, the contents may be let out: the fixed portion of the bottom is made sloping, so that it may be readily emptied.

About thirteen years ago it occurred to the editor of this work, that the force of the wind might be beneficially employed as an auxiliary power for propulsion on railways; and considering that the suspension principle, which had just then been promulgated by Mr. Palmer, was better adapted to that object than any other, he wrote a short paper on the subject, which was inserted in the eighth number of the *Register of Arts*, for January, 1824, under the signature of "L. H." The plan also embraced a proposition for enabling boats from the sea, a river, or canal, to pass out of the water, at once upon the rail, and thereon be propelled precisely in the same manner as the receptacles provided by the inventor are, and from which they scarcely need to differ in shape. Both of these propositions have been treated with abundance of ridicule, by persons who were either incapable or indisposed to reason. But one of them having, according to the newspapers, been recently carried into actual practice at Sunderland, and under less favourable circumstances, (*i. e.* on the common ground rail,) the writer need not dilate upon its feasibility. And as respects the other propositions, he will only observe, that believing it to contain the germ of something that may hereafter prove of public benefit, he hesitates not to place it before the judgment of the reader. The following are extracts from the paper alluded to. "The inhabitants of small islands, and of the sea-coast generally, subsist chiefly upon fish; and as they are remarkable for robust constitutions, it follows that their food must be strengthening and wholesome. I propose, therefore, a railway, on Palmer's principle, from London to the nearest seaport town or fishing-place, that shall give to the inhabitants of this city the advantages of a plentiful supply of the cheap and wholesome food enjoyed by those in maritime situations. In the drawing which accompananies this, the scene sketched is *entirely* imaginary, and is intended, first, to represent a

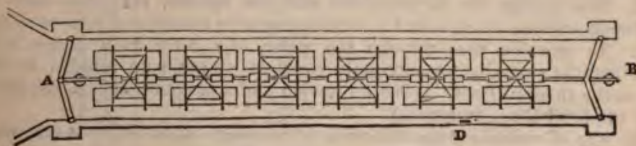
railway leading to a sea-port, with the carriages being propelled, according to the modes projected by Mr. Palmer; the first train of carriages being drawn along the rail by a locomotive steam-engine, the second, more in the perspective, is supposed to be drawn by a horse. Brighton is perhaps the most eligible situation for such an undertaking. By a railroad from that place, the London market might be supplied with a prodigious quantity of fish within three or four hours after their being taken from the sea, at the most trifling expense of car-



riage; and if the wind were to be employed as an *auxiliary* propelling force, which I propose, the rapidity with which the fish might generally be brought to our markets would give us all the advantage of a sea-port town in the purchase of it. If the Hollanders have found it practicable (as is well known) to sail over *land* in four-wheeled carriages, how much more practicable and advantageous would it be to bring into use the admirable facilities furnished by Mr. Palmer in his new suspension railway, in which the resistance to the motion of the carriages is reduced to one-twentieth part; or in other words, wherein the facilities are twenty times greater. As objections will of course be raised, on the score of the variableness of the wind, I must repeat, that I only propose it as an *auxiliary* power. It would rarely happen that the wind would not be favourable in going or returning; and it is well known that S.W. winds prevail more than any other in our quarter, which would be favourable for the principal traffic; that is, to London. In the absence of a steam-engine, a horse should always be in attendance; so that when employed in drawing a train of carriages, if a favourable breeze should spring up, the sails might be spread, and the horse be put into one of the receptacles, where, over his bag of corn, he might regale and invigorate himself for fresh exertions, should the wind fall off.

"Having now given the outline of my first project, I proceed to my *second*, which will explain the meaning of the sailing vessels in the foreground of the drawing, that are apparently issuing out of a canal lock. My intention in this was to exhibit an easy and obviously practicable mode, of transferring heavily laden vessels directly out of the water on to the railway, where they might be *propelled* by the wind with much greater velocity than through the water; and *at the same time* show how admirably Mr. Palmer's railway is adapted as a

branch communication to and from canals and rivers, or to form an important connecting line between them. In cutting a canal, which has to proceed down a declivity, and to ascend another, numerous locks must be constructed at an enormous expense; these would cause great loss of time and inconvenience in the traffic, which may be obviated by the adoption of this suspension railway as a connecting communication. The railway I propose is to be constructed as usual, elevated upon pillars, and not to terminate on arrival at the lock gates B, but to pass over it, and terminate at the other end, just within the second gates A, and be supported upon pillars from the floor of the lock, the same as on dry ground. In the annexed cut, (which is a plan,) the double train of vessels are supposed to have all entered the lock, half on one side of the rail, and half on the other, and they are hooked on to the axle-trees of the wheels which, are already upon the rail for that purpose. The gates next to the

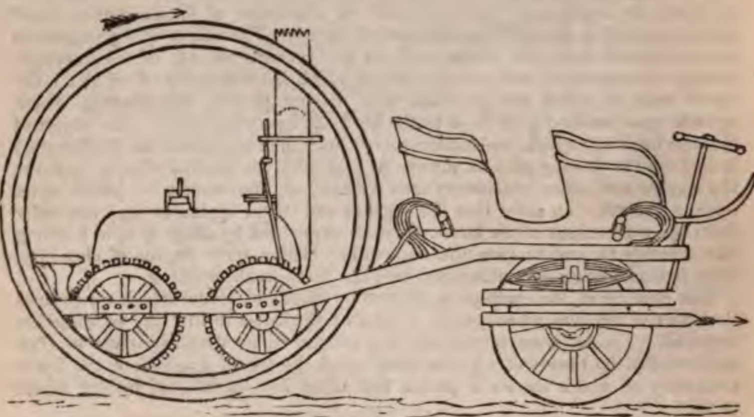


river or canal are then closed, and all being fast, the water is let out of the lock by a sluice at D, till it falls below the bottom of the outer gates; at which time the vessels are all suspended on their axles in the air. The gates being next opened, and the wind fair, they sail across the valley, or are propelled by the other means provided by the patentee."

Having now noticed the principal arrangements in several different kinds of railways, and the motive power employed, we shall proceed to inquire into the nature and extent of the effects produced. The resistance to the motion of carriages arises from three causes, whether travelling on the common road, or on railways; but they vary in their relative proportions according to the nature of the surface passed over. Thus the resistance to the motion of a carriage on the common road, arising from the obstructions or inequalities of the surface, to the rolling of the periphery of the wheels, is greater than that of the rubbing at the axles; while on a railway, owing to the smoothness of the surface, the contrary is the case. According to the experiments made by Mr. Stephenson and Mr. Wood, the resistance *at the periphery of the wheels* on a good level railway does not exceed about a thousandth part of the insistent weight, while the same kind of resistance upon an ordinary turnpike road, according to our own observations, does not average less than a twenty-fifth part; or forty times that of the railway. It is from the reduced amount of this, the first mentioned kind of resistance, that railways possess such great advantages for locomotion; for in the second kind, that of the axles, the difference of friction cannot be material, nor can the resistance from air, (the third kind,) be at all different, presuming, of course, that the opposed surfaces and the velocities are the same in each.

Mr. Palmer, in his description of his railway, justly remarks, that if some accurate means of ascertaining the resistance of roads and railways were on all occasions used, their improvement would be much advanced. The real value of either being then unequivocally compared, the amount of defect could no longer be a matter of mere opinion. The proprietors would then know whether an apparent inferiority arose from the difference of horses, or difference of circumstances; and it would be of great advantage to introduce a clause in contracts, which would determine the effect to be produced. The methods by which resistance of roads and railways has been ascertained, have not been sufficiently accurate, or have been too inconvenient for general use. The dynamometers, which denote the resistance by the degree of *extension given to springs attached to the carriage*, are convenient as portable instruments, but do

municated to the wheels of the carriage, causes them to revolve, and to climb up the internal rack of the large cylinder; the centre of gravity of the engine being thus constantly made to change its position, and to throw its chief weight on the forward side of the axis of the cylinder, the latter is compelled to roll forward, propelling the vehicle before it, and whatever train may be added to

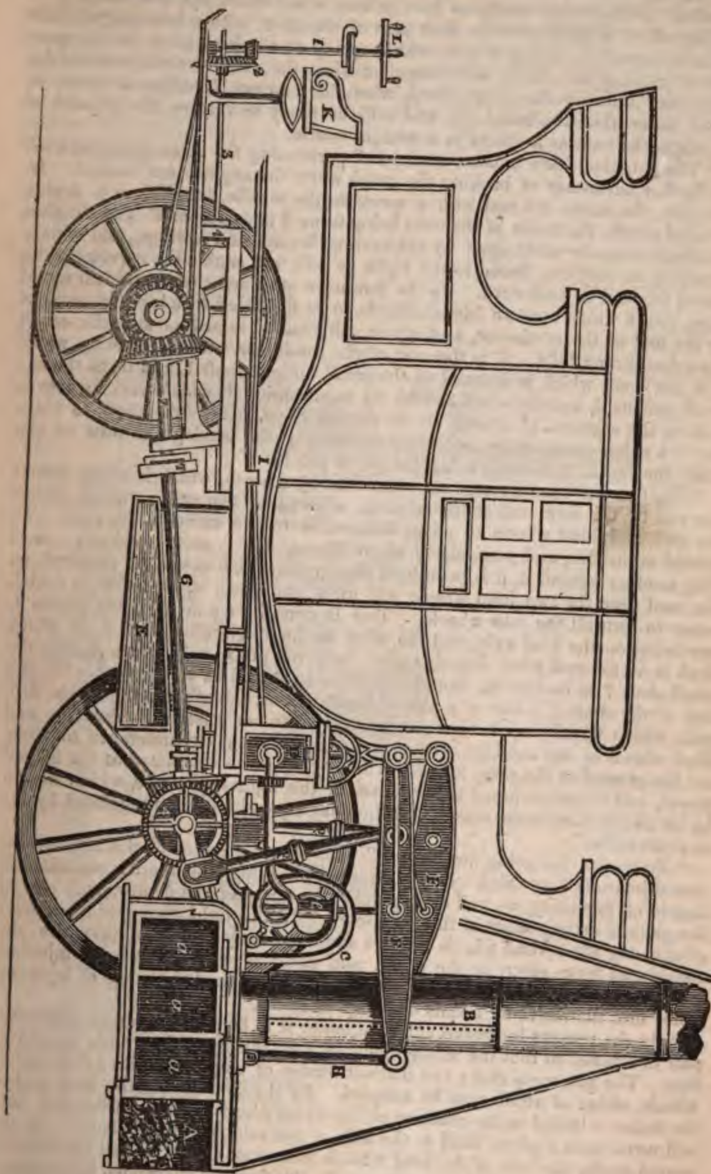


the hinder part. As an example of the utility of this machine, Mr. Alexander Gordon states, that he has lately been informed by Mr. Samuel Moyle, that at a subsequent date, he had used a large drum of this kind with great advantage, for the transport of heavy goods over a swamp, in South America. "Having a quantity of plate iron, which was too heavy to carry over otherwise, he rivetted the plates together into the shape of a large cylinder, and carried over heavy goods in the inside of it. As the party advanced, this huge machine rolled with them. Having arrived at their destination, the rivets were cut off, and the plates applied to their intended use. Now it will be obvious that a roller of this kind, so far from deteriorating a road, must materially improve it, and it may not inappropriately be termed a *movable rail-road.*"

On the 3d of February, 1824, a patent was granted to Mr. T. Burstall and John Hill, of Leith, for a locomotive steam carriage; an account of which was first given in the *Edinburgh Journal of Science*, whence we derive the following description.

"A represents the boiler, which is formed of a stout cast-iron or other suitable metal flue, inclosed in a wrought-iron or copper case, as seen in section, where A is the place for fuel, and *a a a* are parts of the flue, as seen in section, the top being formed into a number of shallow trays or receptacles for containing a small quantity of water in a state of being converted into steam, which is admitted from the reservoir by a small pipe. B is the chimney, arising from the centre flue; at D are the two cylinders, one behind the other, which are fitted up with pistons and valves or cocks, in the usual way, for the alternate action of steam above and below the pistons. The boiler being suspended on springs, the steam is conveyed from it to the engines, through the helical pipe *c*, which has that form given to it to allow the vibration of the boiler, without injury to the steam joints. E is the cistern containing water for one stage, say 50 to 80 gallons, and is made of strong copper, and air-tight, to sustain a pressure of about 60 pounds to the square inch. At *e* are one or more air-pumps, which are worked by the beams F E of the engines, and are used to force air *into the water vessel*, that its pressure may drive out, by a convenient pipe, the

water into the boiler, at such times and in such quantities as may be required. The two beams are connected at one end with the piston rods, and at the other



with the rocking standards *H H*. At about one-fourth of the length of the beams from the piston rods are the two connecting rods *g g*, their lower ends

structed upon a scale of three inches to the foot, which embraced these improvements. It was publicly exhibited in Edinburgh, and afterwards in London, where it was made to travel round a circle of 17 feet diameter, on an uneven deal floor, with a speed equal to about 7 miles per hour. A deal platform, 18 feet long, rising 1 foot at the end (or 1 in 18) was fixed, which the carriage ran rapidly up without apparent effort. On the outside of the circle was a deal bank which rose 5 in 25, in the cross section, which was used to show that there was no liability of upsetting the carriage even by such uneven ground, owing to the position of the centre of gravity being very low. The representation of this model, on the preceding page, and the description of the machine, we extract from the *Register of Arts* published at that period. "The length of the model is 5½ feet, and its height 22 inches. The steersman sits in front, and by turning a circular horizontal plate *c* gives the first pair of wheels a direction to the right or the left, as may be required. The boiler *b* is of a conical form, and is supported by an iron frame, extending from the second to the third pair of wheels. The fire is in the middle of the cone, and the water and steam outside. The engines are of the high pressure kind, and the boiler is of copper, calculated to sustain ten times the force of the intended working pressure of the steam. Two cylinders are employed, they occupy the hind boot, and rest on the axle of the middle wheels; in the model the cylinders are three inches in diameter, and have a three-inch stroke. The cistern is at *a*, whence the water is pumped by the engine, and forced into the boiler; *e* is the induction steam pipe, *i* the eduction pipe, leading to the chimney, wherein the waste steam being expanded by the heat, escapes invisibly, while it increases the draught, and combustion of the fuel. When the writer saw this interesting model at work, he was informed by the partner of Mr. Burstall, that it had, during the preceding eight days, ran as many times round its circular course as amounted to 250 miles; and that during all that period it required no fresh packing or repair whatever.

On the 15th of May, 1824, Mr. W. H. James (a gentleman of superior mechanical talents) of Birmingham, obtained patents for "an improved method of constructing steam carriages;" the chief peculiarity in the arrangement of which consisted in adapting separate engines to the gear of each of the propelling wheels, instead of actuating them uniformly by the same engine, whether the latter consists of one or two cylinders. Mr. James's design was to use very small cylinders, and work them with steam of very high pressure, so as to obtain the utmost compactness, and the least weight that might be practicable. The motive of employing separate engines was that each wheel might have a motion independent of any of the other wheels, so that their powers or velocities might be varied at pleasure, which he considered to be essential in passing round curves, or turning corners of the road, because, when a carriage moves in the arc of a circle, the outer wheel moves over a greater space of ground than the inner wheel, and would consequently render it necessary for the engine connected with the outer wheel to work so much faster than the engine connected with the inner wheel. Mr. James's mode of effecting this operation was by a very simple contrivance: he caused the fore axletree to be connected with a stop-cock placed in the main pipe, through which the steam passes from the boiler to the respective engines; and this stop-cock was so constructed, that when the fore axletree stood at right angles to the perch (*i. e.* when the carriage was proceeding in a straight line) it admitted equal quantities of steam to each engine; but whenever the axletree stood obliquely to the perch (as in making curves) it caused the stop-cock to admit a greater quantity of steam to the engine connected with the outer wheel, so as to cause that wheel to revolve faster, and a diminished quantity to the engine connected with the inner wheel, so as to make it revolve slower, in exact proportion to the curve around which the carriage was moving.

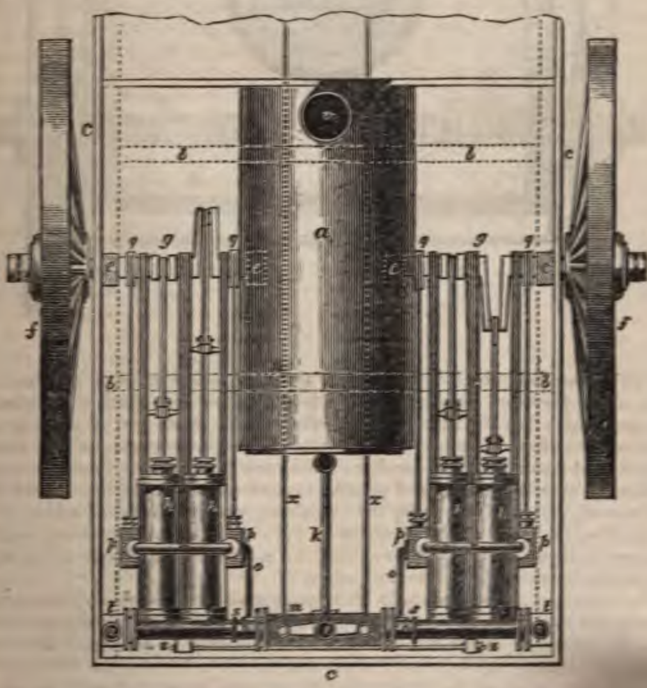
Upon roads having steep ascents, Mr. James proposed to employ four engines, or one to each wheel, for the purpose of obtaining a greater degree of resistance *upon* the surface passed over: but in roads of ordinary undulations, two engines *were deemed sufficient*; the wheels do not require to be thrown out of gear, but

in passing round curves may be kept constantly in action, so as to preserve the amount of friction upon the surface pretty uniform. In passing down a hill, however, or whenever it may be desired, a wheel may be locked or dragged, as in other carriages.

Another leading object with Mr. James was to put the whole of the machinery upon springs, to prevent the injurious consequences to the acting parts, by the concussions of a stony road, and at the same time allow of the uniform operation of the engines upon the running wheels, when passing over rugged surfaces. To this end Mr. James caused the engines and their frame-work to vibrate altogether upon the crank shafts as a centre; at the same time connecting these engines to the boiler and exit passages, by means of hollow axles moving in stuffing-boxes, which, together with the body of the carriage, is suspended upon springs, that are bolted to the axletrees.

Fig. 1, in the following cuts, exhibits a plan of the machinery of a carriage, as applied to the hind wheels. *Fig.* 2 is a cross section, giving an end view of the

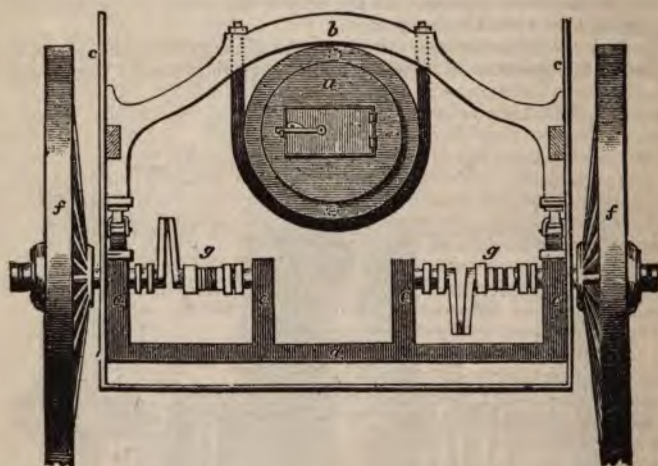
Fig. 1.



boiler and the cranks, showing the manner in which the former i
its mode of attachment to the body of the carriage, and
springs on which it rests: similar letters of reference apply
parts in each of the figures. *a a* is the boiler suspended
which is connected to the body of the carriage *c c*, and
is the axletree, the form of which is best seen in *Fig.* 2; it
the axles of the running wheels *f f* are affixed thereto
one piece with each of the crank shafts *g g*, by whic
revolve independently of the other. Each of these

h h, which operate by their piston rods upon the cranks; to these separate engines steam is applied from the boiler *a a*, by means of the pipe *k*, which enters at the stop-cock *l* into the steam-box *m*; from this box the steam passes into the pipes *n n*, which move steam-tight through stuffing-boxes; from thence the steam proceeds through the pipes *o o o* to the slide boxes *p p p*, the slides being worked by eccentrics *q q q*, in the crank shafts, in the usual manner, and thence to the cylinders. The exhaustion pipes *r r* lead into the hollow axles *n n*, before described, in which there are partitions *s s*, to separate the steam from

Fig. 2.



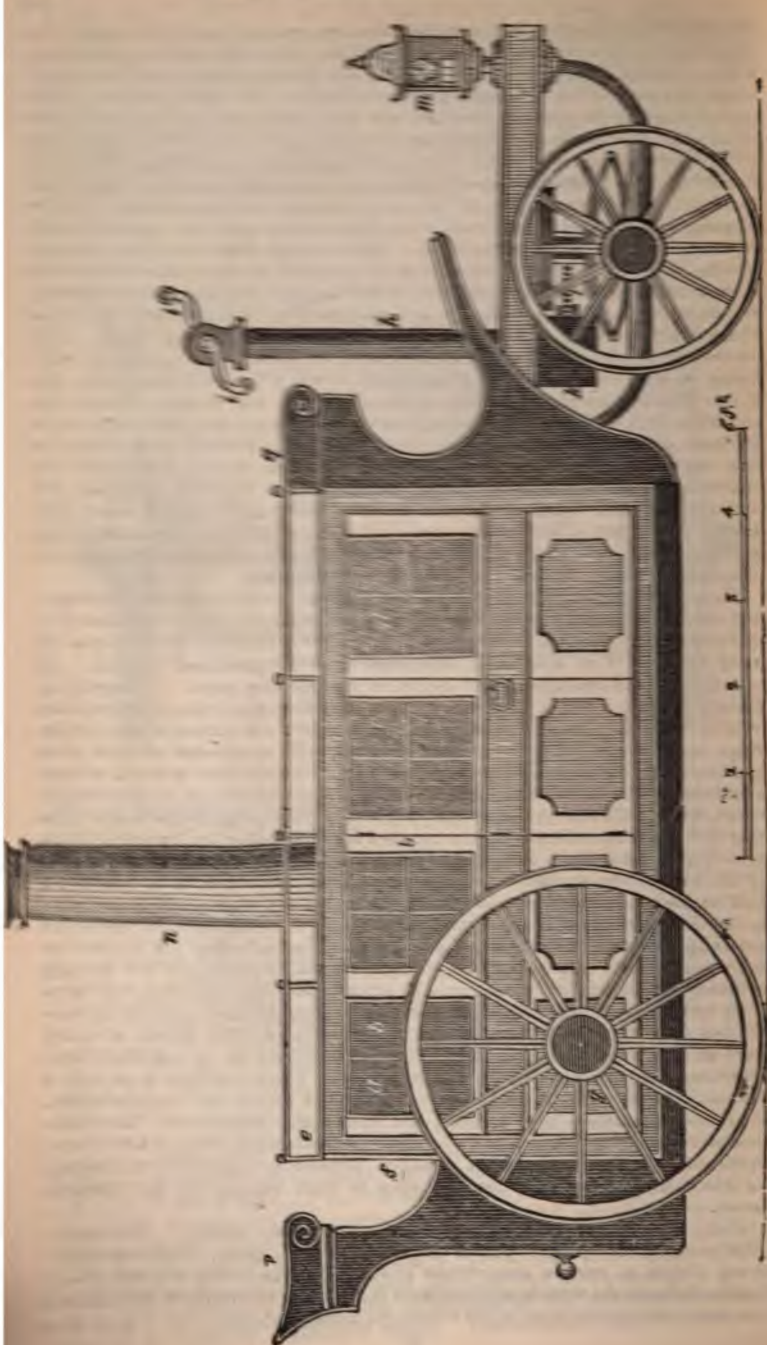
the exit passages, which pass through the said hollow axles to the boxes *t t*, from which there are pipes *u u* leading to the chimney *v*, where it is thrown off in a jet, which has the effect of increasing the draught, and of exciting combustion of the fuel. The rods *x x* are attached to the fore axle of the running wheels, and also to the two handles of the cock *l*, so that the fore axle and the cock move simultaneously, and parallel to each other; *z z* represent part of the frame-work extended, for tying the engine together by means of a bolt, and so as to allow the body of the carriage to have a slight lateral motion upon its springs, independently of the engines, by means of the hollow axles sliding longitudinally through the stuffing-boxes.

The principal arrangements in this locomotive engine are ably designed to accomplish the object in view; but the intelligent inventor (owing, we believe, to some pecuniary disappointments) was not enabled to prosecute the undertaking of building *carriages* until some time afterwards. In the interim, however, he was engaged in other scientific pursuits connected with locomotion, and in the construction of a boiler capable of generating steam of very high pressure, with perfect safety: he also occupied himself in the application and adaptation of small high-pressure engines to the generating apparatus; and on the 5th of March following he took out a patent for a tubular boiler, which was decidedly the most effective machine of the kind that had then been invented. It consisted of a series of annular tubes, of equal capacity and diameter, placed side by side, and bolted together, so as to form by their union a long cylindrical boiler, somewhat similar in external figure to that shown in *Fig.* 1, but from being made of small tubes, capable of resisting full one hundred times the pressure of an ordinary cylindrical boiler. This excellent apparatus being fully

described in the Engineer's Ency. Art. Boilers, we shall not here extend the description, and have only to observe that it was with boilers of that description, and a carriage slightly modified from the one just described, that Mr. James, about two years after, commenced the construction of steam carriages. This undertaking, in its progress, promised the most favourable results, the experiments that were made demonstrating the certainty of the ultimate accomplishment of perfect success; but a failure in his pecuniary resources prevented its consummation. Some friends of ours assisted at some experiments made with the first carriage, on the 5th of March, 1829, over a rough-gravelled road in Epping Forest, which it traversed, with fifteen passengers, at a speed varying from twelve to fifteen miles per hour. This carriage was exceedingly clumsy, having been repeatedly cut and altered, as successive changes were made in the disposition of its parts for experiment, and it weighed, including the machinery, rather more than three tons. It had two working cylinders, only 3½ inches diameter, the power of which was applied to the hind running-wheels. The steam was supplied by two tubular boilers, of the before-mentioned kind, each being a cylindrical annulus of one-inch tubes, 4 feet 6 inches long, and 1 foot 9 inches internal diameter, wherein the fire was placed. During the experiments, one of the tubes (which were the common gas pipes) opened in its seam, and consequently all the water of that boiler escaped, extinguished its fire, and reduced the intensity of the other, there being a communication between them. Thus circumstanced, with only one boiler in operation, the carriage returned home, at the rate of seven miles an hour, with more than twenty passengers, demonstrating thereby this remarkable fact,—that a sufficient power of steam can be generated in so small a boiler, as to be adequate to the propulsion of about 4½ tons weight on the common road.

Shortly afterwards, the proprietors commenced building another carriage; but they experienced considerable difficulty and delay in getting the tubes of a suitable quality of metal, and the joints properly constructed; so that it was not until the month of November, 1829, that they brought it out for trial. An elevation of this machine is represented in the following page. As denoted by the scale of feet, it was of small size, being designed to operate as a drag to another vehicle behind. The boilers were four in number, and instead of the tubular rings being circular, they were made elliptical, with compressed sides, so as to get four of them side by side across the carriage. This was done to obtain as large a surface of metal as possible exposed to the heat of the furnace, as, by this arrangement, nearly 200 tubes, measuring upwards of 400 feet, were enclosed in a space four feet wide, three feet long, and two feet deep, including the furnaces, (which were inside the boilers) besides the flues and ash-holes. The steam from each of the boilers was conducted into one very strong tube above, of an inch and a half in diameter, to supply the engines; each of the pipes of communication to it being provided with stop-cocks, to cut off the communication of any boiler that might become unserviceable by leakage, without affecting the pressure on the other boilers. The power was applied through the medium of four working cylinders, which might be considered as separate engines, being fitted so as to work independently of each other, although they might more properly be considered as pairs, each pair acting upon a distinct crank, (the throws of which were at right angles to each other,) that gave motion to its respective hind wheel, on the principle described at page 454. These cylinders were only a foot long, three inches and a half outside, and two inches and a quarter inside, diameter; the pistons were metallic, and made a nine-inch stroke. The cylinders were posited vertically, and vibrated upon trunnions, through which were made the induction and eduction passages, covered by conical valves, forming an external shell to the trunnions, close to their bearings in the plummer boxes.

These engines were arranged at *a*, in a row across the carriage. The steam, after working the engines, passed through two copper tanks, which heated the water therein to such a temperature above boiling as to melt the soft solder externally upon the vessels, and rendered it necessary to substitute hard solder; the steam was carried then to the chimney-funnel to escape. At *c* is a door,



which space across the carriage, and also that at *d*, were for the use of the man who attended to the furnaces and boilers, besides being used as a receptacle for fuel: at the sides, roof, and bottom of this room were plate-iron shutters, to afford constant draughts of air, that the heat might not be insupportable. The engineer sat on the hind seat *p*, and at *e*, over the engines, was a sheet-iron flap, like the lid of a box, and at *f* sliding-doors, enabling the engineer to keep his eye upon the working parts, and, by his spanner, and other tools, to rectify, if required, any slight defect that might take place; his situation likewise permitting him to give directions to the furnace-man, and to hold communication with the guide, who sits on the box *g*. At *h* is the steering apparatus, consisting of an external case, containing a vertical shaft, at whose upper end is fixed a beveled pinion, which is acted upon by a small beveled wheel, fixed into the axis of the double-handled winch *i i*. By turning these handles, therefore, the shaft is caused to revolve, and to give motion to a gear at the lower extremity, which acts upon a toothed sector *l*, attached to the fore axle-tree, and thereby turns the fore wheels into the required positions. The lower gear, which is contained in a box *k*, is adapted to increase the force with a reduced motion, so that the guide, who is able to turn the handles *i i* quickly, operates with great energy upon the toothed sector, and to overcome with facility the most prominent of ordinary obstacles in the road. This guiding action being administered by a multiplying power, through the complex medium of toothed wheels, was found to be far more effectual and convenient than when a long lever of a more simple form was used; besides, that the latter was somewhat dangerous to the guide, who was rendered liable to receive severe blows by the motion of the long handle, when the wheels happened to be turned aside by the opposition of stones laying in the road. At *m* is a lamp, not only useful for lighting the road before the carriage, but serving also (as the prow of a vessel to a mariner) to steer by. The chimney-funnel was made double, the space between the external case *n* and the internal smoke flue *o* being for a current of air to prevent the otherwise unpleasant radiation of heat laterally. The fuel preferred was a mixture of coke and wood charcoal, which produced a great heat, and gave but little black smoke. The motion was communicated to the separate axles of the hind wheels by spur gear of two velocities, changeable at pleasure, as the state of the road, or other circumstances, might require; this gear was enclosed in boxes, shown at *h*, and the whole machine was placed upon springs, except the guiding apparatus, which was purposely arranged otherwise, as exhibited in the engraving. This carriage was only taken out of the yard (where it was built) three times: on one of these occasions the writer accompanied it three miles, which it performed in twelve minutes; after which a joint of the induction pipe failed, through which the steam escaped into the air instead of entering the cylinders; this accident, of course, soon brought the carriage to a stop. Every person who witnessed this experiment was perfectly convinced of the feasibility of the scheme, and that nothing was wanting but a little more experience in discovering and remedying the weak points, which practice alone could effect. The patentee was not, however, afforded the opportunity of obviating the defects he had discovered in some parts of his arrangements, from the want of that support which other men of less talent, but more assuming conduct, easily obtained in abundance. One of these defects consisted in crowding the engines and machinery into too small a space, which, while it rendered accurate fitting and repairs difficult, occasioned some parts to be brought into violent collision by the vibrations of the carriage over a stony road. Another great defect (which was about to be altered) consisted in the iron ring or tire of the wheels being only *one inch and a half wide;* in consequence of which, the wheels sank into the ground at least twice the depth of others, having tires of double the width: an acclivity was thus constantly formed before the wheels, which they had either to ascend, or to crush down, causing, in either case, a considerable waste of power. Much ground, it may be observed, that will resist compression entirely from a broad wheel, and allow the carriage to roll over it easily, will give way under a narrow wheel, and so raise up a constant oppostion to its own progress. The chief disadvantages of broad tired

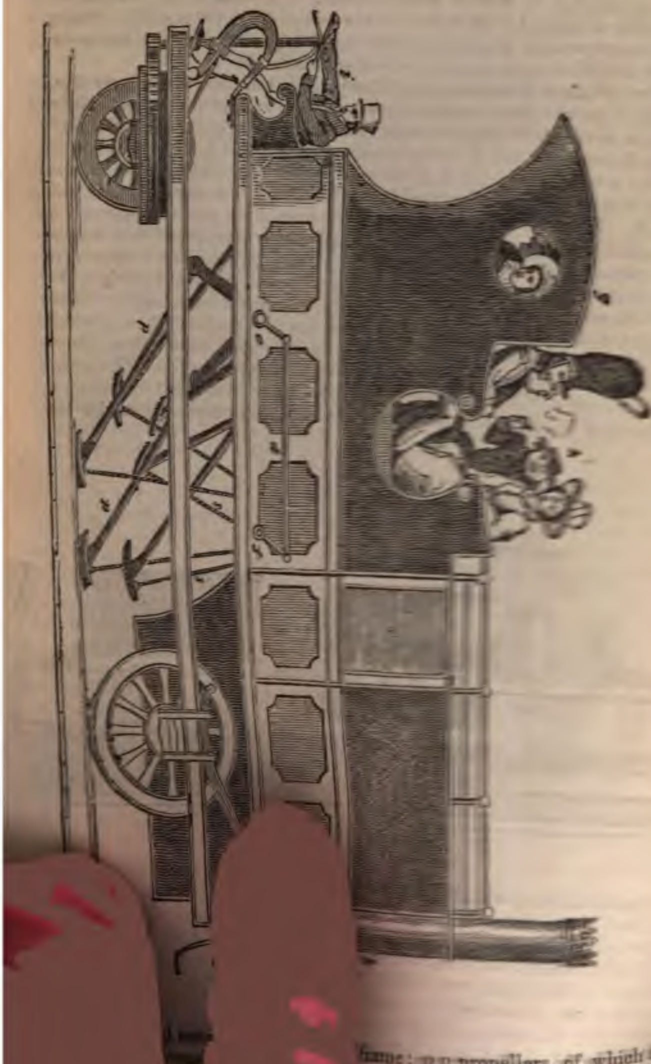
wheels consist in their superior weight, and their greater liability to encounter loose stones lying on the road. The narrower a wheel is the better, provided it does not leave an impression on the road; but as wheels should be made to suit all the various conditions of the road on which the carriage has to travel, a medium between the extremes should be chosen, which is probably about three inches' width of tire to every half ton that a wheel has to bear. It may be further noticed, that in every experiment made with this carriage, those parts which exhibited a defective action could always be traced to an evident cause; and although the remedy was also rendered obvious, it could not always be carried into effect without considerable delay and expense, which, to the capitalist who is ignorant of mechanical combination, was naturally discouraging. It will, however, be generally found, that those individuals who have had the most experience in undertakings of this kind, have never discovered, in the obstacles that have hitherto presented themselves, any thing of an insuperable nature, as to its ultimate success.

The next attempt to construct locomotive carriages for the common road, was by the late Mr. David Gordon, whose patent was dated the 18th of December, 1824. The means proposed by this gentleman for propelling, was a modification of the method invented by Brunton, and described at page 31. But instead of the propellers being operated upon by the alternating motion of the piston-rod, Mr. Gordon contrived to give them a continuous rotatory action, and to apply the force of the engines in a more direct manner. The following cut affords an external view of one of Mr. Gordon's designs, in which the patented mechanism is introduced. The carriage ran upon three wheels; one in front to steer by, and two behind to bear the chief weight. Each of the wheels had a separate axle, the ends of which had their bearings upon parallel bars, the wheels rolling in a perpendicular position. This arrangement, by avoiding the usual cross axle, affords an increased uninterrupted space in the body of the vehicle; and was the subject of an antecedent patent granted to Mr. Gordon.

In the fore part of the carriage were placed the steam engines, consisting of two brass cylinders, in a horizontal position, but vibrating upon trunnions: the piston-rods of these engines gave motion to an eight-throw crank, two in the middle for the cylinders, and three on each side, to which were attached the propellers; by the revolution of the crank, these propellers or legs were successively forced outwards, with the feet of each against the ground in a backward direction, and were immediately afterwards lifted from the ground by the revolution of another crank, parallel to the former, and situated at a proper distance from it on the same frame. The propelling-rods were formed of iron gas tubes, filled with wood, to combine lightness with strength. To the lower ends of these propelling-rods were attached the feet, of the form of segments of circles, and made on their under side like a short and very stiff brush of whalebone, supported by intermixed iron teeth, to take effect in case the whalebone failed. These feet pressed against the ground in regular succession, by a kind of rolling, circular motion, without digging it up; and it must be acknowledged that Mr. Gordon, in these contrivances, succeeded in avoiding the injurious effect upon the road that would otherwise have been caused by this mode [illegible] propelling. The guide had the power of lifting these legs off the gro[illegible] pleasure, so that, in going down hill, when the gravity was sufficient [illegible] sion, nothing but a brake was put into requisition to retard [illegible] necessary. If the carriage was proceeding upon a level, the [illegible] pellers was equivalent to the subtraction of the power, and [illegible] stoppage; and in making turns in a road, the guide [illegible] pellers on one side of the carriage, and allow t[illegible] othe[illegible] the cure is traversed.

The following engraving represents a s[illegible] end of the boiler; *b* the flue; *c* an apar[illegible] fire and regulate the machinery, whi[illegible] coke, &c.; *d* external connecting-ro[illegible] actuates the driving cranks of the pr[illegible] *carriage; e* being the axis of the [illegible]

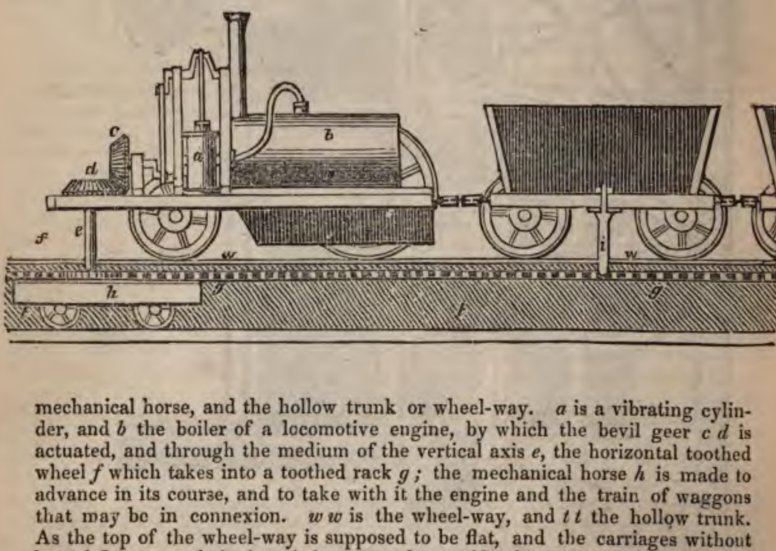
cranks; *g* the apartment for the inside passengers, which has glazed windows in front; *h* the seats for the outside passengers; *i* the conductor, who guides the carriage by means of four cross levers, turning a small toothed pinion, that



frame; *p p* propellers, of which the
by which the propellers are lifted
were made with this carriage on
of propulsion was proved, how
inadequate to produce the required
becoming afterwards
the running wheels (as instead
and therefore preferable to

The next invention in the order of time that presents itself to our notice, is one possessing considerable originality; and though it has not been carried into effect, it contains some ingenious and amusing suggestions, that have formed the groundwork of subsequent inventions. It is the subject of a patent granted to William Francis Snowden, of Oxford-street, London, on the 18th of December 1824, for a "new invented wheel-way and its carriages for the conveyance of passengers, merchandise, and other things, along roads, rails, and other ways, either on a level or inclined plane."

The specification describes the invention under two distinct heads; the first, as respects the wheelway, explains it as consisting of a hollow trunk with a platform of iron on the top for waggons or other carriages to roll upon; inside the trunk is placed a machine, called by the patentee a mechanical horse, to which is connected a toothed wheel, that is made to revolve in a horizontal plane, and to take into the teeth of a horizontal straight rack fixed on one side of the hollow trunk. The vertical axis of the horizontal toothed wheel passes through a longitudinal opening in the wheel-way; above which it is connected to a locomotive steam-engine, and is actuated thereby; through the medium of bevil geer the motion thus communicated to the latter by the engines, is applied by the vertical axis to the horizontal wheel of the mechanical horse, inside the hollow trunk; and as the horizontal wheel is geered into the toothed rack, which is *fixed* on one side of the trunk, the mechanical horse of necessity moves forward with the same velocity as the horizontal wheel is made to revolve by the power of the engine. Those to whom our literal description may not be clear, will understand it by the annexed figure, which affords a longitudinal section of the



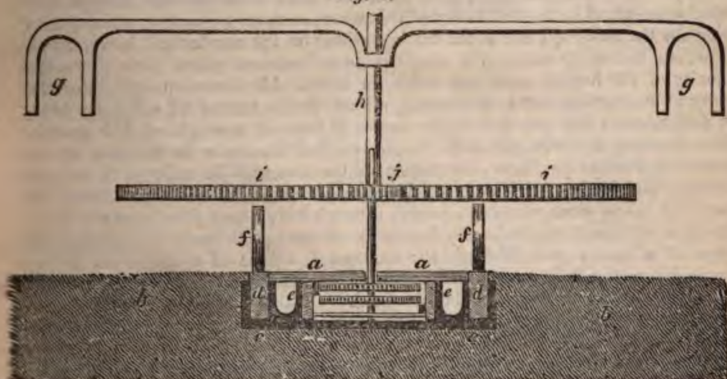
mechanical horse, and the hollow trunk or wheel-way. *a* is a vibrating cylinder, and *b* the boiler of a locomotive engine, by which the bevil geer *c d* is actuated, and through the medium of the vertical axis *e*, the horizontal toothed wheel *f* which takes into a toothed rack *g*; the mechanical horse *h* is made to advance in its course, and to take with it the engine and the train of waggons that may be in connexion. *w w* is the wheel-way, and *t t* the hollow trunk. As the top of the wheel-way is supposed to be flat, and the carriages without lateral flanges to their tires, it is proposed to guide the carriages by means of tongues like that at *i*, which enters the longitudinal aperture, and which may be provided with an antifriction roller to prevent lateral rubbing. The inventor proposes to adopt a similar arrangement to the foregoing for the towing of barges, by erecting his patent wheel-ways by the sides or banks of canals and rivers.

The second head of invention under the patent is of a more singular character, and however preposterous it may at first appear to those who have not considered the subject, it is in reality by no means absurd in principle, nor in the

rationale of the proposition; but we will first describe it, and afterwards make our observations.

Fig. 1.

Fig. 2.



Instead of placing horses *outside* of a carriage to give it motion, the patentee puts them *inside* for that purpose; and his reason for doing this, that of increasing the force or velocity, will to many appear to be quite as paradoxical. The above *Fig.* 1 affords a perspective view of a machine of the kind, and

Fig. 2 a section of the wheel-way and mechanism by which the process of propulsion is effected. This second part of the patent is thus described in the *Register of Arts*:—" *b b* represents a vertical section of the road in which an excavation is made, and the ground well rammed, so as to lay down, at uniform distances, a series of cast-iron frames or sleepers *c c*. In the several partitions of the sleepers are placed, lengthways, four lines of timber. The two principal rails, *d d*, are of oak, and stand about three inches above the level of the other parts. The other two lines of timber, *e e*, are three-inch planks, set on edge, and bolted to the framing. Resting upon these deal planks and the iron partitions, and flush with the oak timber, are laid, crossways of the road, short pieces of three-inch oak plank, leaving an open crevice about one inch and a half wide between them. These short planks are laid edge to edge, uniformly along the whole line, so as to form a level floor, over which is screwed down a complete covering of wrought-iron plates, *a a*. On this hard and level surface, the wheels of the carriage are intended to roll. Inside the hollow trunk is the mechanical horse, which is actuated by motive force applied above, through the medium of similar gear to the before-described. Only two-toothed wheels are shown in the trunk; there is, however, another, which cannot be seen in this view, which, when put into gear with the opposite rack, reverses the rotatory motion, and causes the carriage to proceed in the same direction. The lowest wheel of the three shown is made light, as it only operates as an antifriction roller, and for that reason occupies the whole space between the two three-inch deals. The perspective sketch in *Fig.* 1, though rather disproportioned in some of its parts, exhibits a carriage of the kind described in the specification. It consists of two stories,—the upper one for passengers, containing both inside and outside berths; and the lower one for merchandise, which is deposited on a circular floor, around which two horses are made to work, as in a mill, being yoked to the two opposite extremities of a horizontal lever, that turns a vertical axis, to which is connected multiplying gear that causes the mechanical horse in the hollow trough, and the carriage above, to move at any predetermined velocity of motion; the horses, however, continuing to move at that slow pace (of about $2\frac{1}{2}$ miles per hour), by which they can most efficiently exert their force. The diagram marked *Fig.* 2 is explanatory of these motions: *g g* are two yokes, to which the horses, being attached, give motion to the horizontal lever and the vertical shaft *h*, on which is also fixed, close under the floor of the carriage, a large horizontal spur-wheel *i*; the revolution of this wheel actuates a pinion *j*, which pinion being on the same spindle as the toothed wheel on the mechanical horse, which takes into the rack, causes the carriage to advance at about four times the velocity of the horses, or at ten miles an hour. Mr. Snowden calculates the power of an average horse, in drawing a load, at the rate of $2\frac{1}{2}$ miles per hour, for four hours a day, as equal to the constant force of a weight of 250 pounds, when drawing in a straight line: if the speed of the horse be doubled or increased to 5 miles per hour, his power of traction will be reduced to only 50 pounds; and if the speed be again doubled, or made 10 miles per hour, the horse can do no work whatever, except through only a very short space of time. The slow motion, therefore, is by far the most favourable mode of applying the power of a horse; and although the contracted circuit of a mill-walk is unfavourable to the full exertion of his powers, Mr. Snowden estimates that a force of about 200 pounds may thus be obtained. Of this available force he proposes to sacrifice three fourths, by means of multiplying gear, into velocity; and thus enable each horse to give out, in effect, a force of 50 pounds at 10 miles per hour; whereas, if the horses were to move themselves at that velocity, they would be totally ineffective. If, therefore, we consider *two* horses to bestow a force of 100 pounds, and that the resistance on the patentee's wheel-way is no more than that of the Manchester and Liverpool railway, namely, 1 in 240, we have $100 \times 240 = 24000$ lbs. propelled by two horses, at the rate of 10 miles an hour. But the friction of such machinery must be considerably *more than 1 in 240*, and the above-estimated force of a horse moving in a circle *of 16 feet diameter*, is probably much too high. Let us therefore suppose the

useful effect to be only half, reducing it to 12000 lbs. The popular objection to this plan, is the apparent absurdity of the horse having to carry his own weight; but this objection equally applies to the steam engine, or any other locomotive power: the whole question, however, resolves itself into one of convenience and economy, as applied to particular cases and circumstances, which we cannot here discuss; and as we shall have occasion, in our account of Brandreth's Cyclopede, to notice the subject again, we shall here conclude with the remark, that we believe it is worthy of the consideration of the machinist to devise the most perfect locomotive machinery, for converting the force of a horse at a slow motion, into a higher velocity with a diminished force.

To enable locomotive carriages to ascend steeper inclined planes than had heretofore been considered practicable, and likewise to enable the carriages and trains to wind round curves in the road, without the severe friction and straining to which they had been previously subjected, was the object of a patent granted on the 5th of March, 1825, to Mr. W. Henry James, of Birmingham, whose common road locomotive is described in the preceding pages. This invention has not, we believe, been carried into effect on the great scale; but we have been credibly informed, that the most satisfactory proofs have been afforded of the ability to effect this, by repeated trials on a railroad more than a hundred feet in length, laid down for the purpose of experiment, on which it was found that a train of carriages would (with the patentee's machinery,) ascend inclined planes three inches in the yard, which is equal to 440 feet in the mile. This important advantage is gained by applying the power to the axletrees of the wheels of the several carriages in the train, by means of the rotation of a long horizontal rod (or series of connected rods), actuated by bevel gear under each carriage.

An ingenious plan has also been proposed by Mr. James for enabling the carriages on a railway to pass around turns or curves in the road, without additional friction. For this purpose, the horizontal rotatory shafts, which cause each pair of wheels in the train to revolve, and propel the carriages forward, are connected together by a novel kind of universal joint, which communicates the rotatory motion to each successive carriage, even if so placed on the curves of the roads, that the sides of one carriage shall present to the side of the next an angle of thirty degrees. To cause the carriage wheels to run round the curves of the railway, without the usual destructive rubbing of their surfaces, the rails in those parts are made with several ribs or elevations, and the wheels of the carriages are consequently formed to correspond with those ribs, by their peripheries being grooved in like manner; so that a wheel, in effect, possesses as many diameters as there are variations in the surface of its periphery, by which means it may be made to travel faster or slower, as may be desired.

The following engravings will render these plans intelligible to the reader. *a* is the boiler of a steam-engine; *b* the engine with two cylinders, the alternating motion of the piston in which gives rotation to the crank *c* above; the rods *e e*, attached to the same, being also fixed to the crank of the horizontal shaft *f f f* (which passes under the carriages), causes that to revolve with a similar speed to the crank of the engine. Two square boxes, *g g*, are fixed under each carriage; through these the axletrees of each pair of wheels pass; the rotatory shaft *f* passes also through the boxes above the axletrees, and at right angles with them; each of the boxes *g g* contain a double-beveled horizontal wheel, which presents a circle of cogs in its upper as well as its lower side, and turns upon cross bearings: now the shaft *f* carrying upon it a vertical beveled pinion in each box, takes into the upper circle of teeth of the horizontal wheel, while the under circle of the teeth of the same actuate a beveled pinion on the axletree underneath, consequently compelling the wheels to revolve; and the power being thus applied to every pair of wheels simultaneously, sufficient resistance is obtained, on a smooth surface, to ascend inclined planes of considerable elevation. *u u u u* are the universal joints, which communicate rotatory motion when the carriages are not in a straight line; these, and other moving parts are distinctly shown in *Fig.* 2, which is upon a larger scale. *f f* is the rotatory shaft; *g g* the two boxes, with the front plates moved, to show the

gear inside; *h h* the beveled pinions upon the shaft in each box; *i i* the horizontal double-beveled wheels. The front box *g*, under the carriage, is fixed immoveably to a solid block of wood, *k*; the other box is fitted to a plate *l*, turning

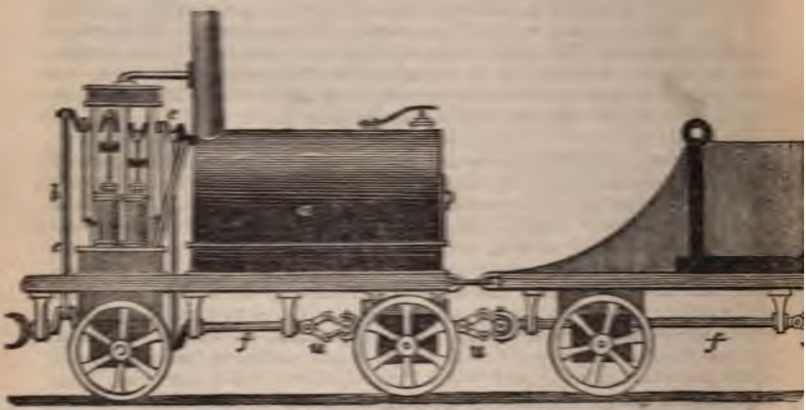
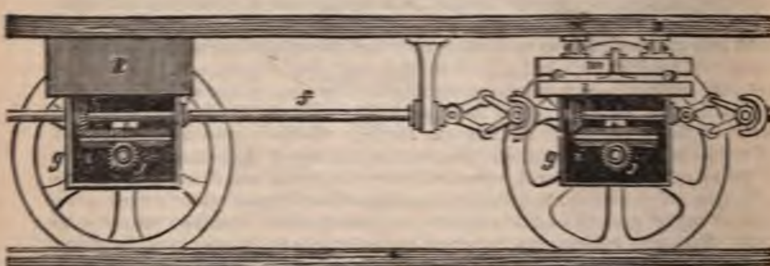


Fig. 2.



on a central point, which passes through another plate *m*, above, the latter being secured to the floor of the carriage by hinge-joints, *n n*. The construction of the universal joints *u u* is also more clearly shown in this figure.

We have now to describe the contrivances by which the patentee proposes to obviate the destructive effects of the rubbing or sliding of the inner wheels of carriages in making curves or turns in a round. If the wheels on one side of a carriage be larger, or of greater diameter than those on the opposite side, such carriage, when propelled, will necessarily make a curve. On this principle the patentee's contrivances are founded. In running along a straight line, the peripheries of the wheels are of equal elevation; but when the carriage has to make a turn, the wheels on one side roll on a greater diameter, or more extended periphery, while the wheels on the opposite side run on a less extended periphery, and the elevations upon the rails on which they run are so adjusted to these variations, that the different peripheries of the wheels change and come in contact with the variable parts of the rail, and run round the curves without any increase of friction.

A *suspension* railway, which in some respects resembles Mr. Palmer's, *described at page* 58, and, in other respects, Mr. Snowden's, described at page

94, was patented by Mr. J. G. Fisher, on the 2d of April, 1825. This gentleman, it will be observed, suspends his carriages to a double line of rail; in this respect, however, he was anticipated in *idea* by Mr. Palmer, who, in his little interesting book, entitled, *Description of a Railway upon a New Principle*, observes,—"to elevate two lines of rail for the purpose of supporting a carriage, could not be done at a sufficiently moderate expense; I therefore endeavoured to arrange the form of a carriage in such a manner that it would travel upon a single line of rail without the possibility of overturning." Nevertheless, if an inventor can succeed in carrying into beneficial operation, that which was thought of by another as ineligible to attempt, he is entitled to respectful consideration.

Mr. Fisher's plan is, however, not without originality, and, with some modifications, may be rendered useful in many situations. The chief object is stated to be the throwing of a railroad across rivers, swamps, &c.; and the means proposed of effecting it will be readily perceived upon inspecting the following diagrams, and referring to the subjoined explanation of them.

Fig. 1.

Fig. 4. *Fig.* 3. *Fig.* 2.

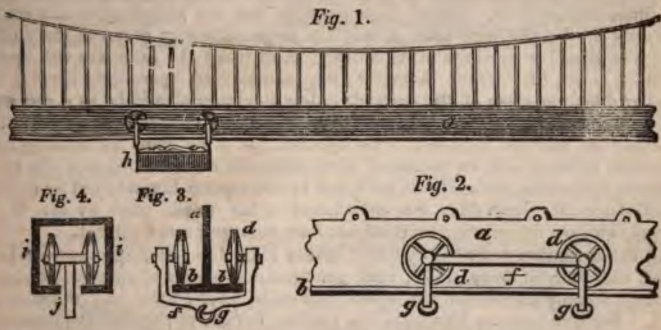


Fig. 1 is a side view of the proposed rail, attached by vertical rods to a chain of bars, which form a catenarian curve; *Fig.* 2 is a similar view, but giving only a portion of *Fig.* 1 on a larger scale; *Fig.* 3 is an end or sectional view of *Fig.* 2; *Fig.* 4 is also a sectional view, but of another form of rail, which we shall describe lastly. The letters of reference denote similar parts in each of the figures. *a* is the rail, made of stout cast-iron plates, of uniform dimensions, bolted together, having a horizontal projection, or plate, *b b*, on each side, for the wheels of the carriages, *d d*, to run upon (seen best in *Fig.* 3); *f f* shows the frame of the carriage: the manner of constructing the wheels on either side of the rail, in pairs, is exhibited in *Fig.* 3, and the mode of joining the front with the hind pair of wheels, in *Fig.* 2. Iron rings, *g g*, pass through the centres of the lower parts of the carriage-frame, to which are suspended the boxes or receptacles for holding the goods or passengers, one of which is shown attached at *h*, *Fig.* 1. The loops or holes in the upper part of the rail *a*, *Fig.* 2, are, of course, for the convenience of bolting it to the suspension bars, as seen connected in *Fig.* 1. Each of the bars is to be provided with a wedge or screw adjustment, so as to regulate the uniformity of the plane when any part sinks. To give an idea of the other form of rail, the section *Fig.* 4 is sufficient. Here it will be seen that the rail (if we may so term it) is of the form of a square tube or hollow trunk, *i i*, with an opening or slit on the lower side for the bar *j* (which is fixed to the axletree of the carriage) to pass through, for the purpose of being connected to a box or receptacle underneath. This square cast-iron trunk, or rail, is to be suspended, as in the previously described rail, to a chain of iron bars or wires, drawn nearly tight, so as to form a catenarian curve when stretched over the place to be crossed.

The *mode of propelling* the carriages is, we believe, not stated in the specifi-

cation, but we understand it is to be performed, when the crossing of rivers or ravines is the object, by elevating that end in which the carriages are placed, and letting them find their way to the other end by their own gravity. By such a proposition, it is probable that the patentee does not intend it for any extensive work, as the means proposed of producing motion are applicable only to such cases as we have mentioned.

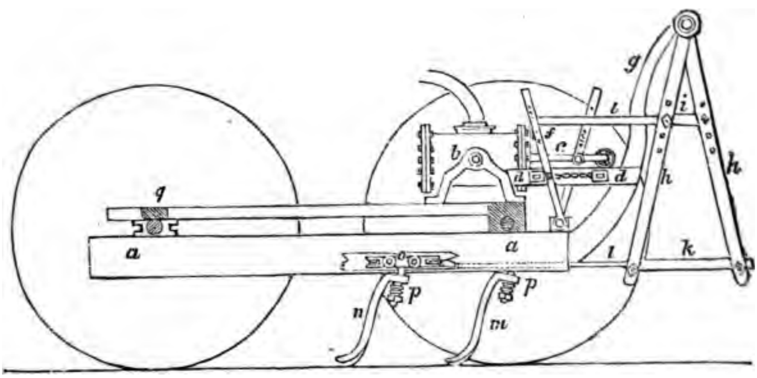
As it is indispensable that carriages which have to run upon edge railways should be provided with wheels that have lateral flanges upon their peripheries to prevent them from running off it; and as such projecting flanges render them inapplicable to carriages on the common road, into which they would make deep destructive incisions, if drawn or propelled over them, it necessarily became of importance to contrive such a wheel, or periphery of a wheel, as would run without detriment on either road or rail. In rummaging over the dusty parchment-rolls of Chancery, we think we have noticed several methods of providing for this object; but that which appertains to our present chronological position is the subject of a patent granted to R. W. Brandling, Esq., of Newcastle-upon-Tyne, on the 12th of April, 1825. The wheels he uses for this purpose have tires, provided, as it were, with two peripheries or external circles of different diameters. Thus, upon an edge rail, the periphery of the smaller diameter of the tire runs upon it, and the larger diameter becomes the guiding flange to keep the carriage in its course. And when the same are run upon a common road, the larger diameter only comes into operation, keeping the smaller diameter clear of the ground, unless the latter should be in a soft state, when it will tend to keep the wheel from sinking deeper in the road. This patentee has likewise included in his specification some plans for making turns or curves in the roads, by means of projecting ribs on the surface of the rail of different elevations, with wheels designed to correspond thereto; but as in these contrivances Mr. Brandling was anticipated a few weeks prior by Mr. W. H James (already described), we shall not here enlarge on the subject.

In the invention patented by Mr. Thomas Hill, Jun., of Ashton-under-Line, dated the 10th of May, 1825, that gentleman proposes to construct a steam-carriage equally adapted to run upon edge-rails, tram-plates, and the common road. For this purpose he makes the guiding flanges removable at pleasure by the withdrawal of bolts, by which they are connected to the fellies of the wheels. Another equally sagacious *invention* consists in making the running wheels of the carriage revolve loosely upon a fixed axletree, which, when applied to railways, he considers to be a new and useful invention. This is, however, a mistake, as they have been so used, but were abandoned on account of their unsteadiness, and other defective action. A third contrivance is to lock the fore-axle to the perch, to prevent its turning round when upon a railway, by means of a square staple entering loops or eyes. A fourth invention consists in making the rails of tubes instead of solid bars, to save metal, and obtain strength. There are some other trifling appendages or alterations to steam-carriages and railroads, for the description of which we must refer the reader, who may want "further particulars," to the enrolled document.

We have now arrived at that period of our narration, (the 14th of May, 1825,) which, according to Dr. Lardner, "is before all others in point of time," when Mr. Goldsworthy Gurney made his debut in the field of locomotion; when, by the "original conceptions of his mighty genius" (or the aid of a very large subscribed capital), he commenced building those steam-carriages, which, after several years' labour of numerous clever workmen, were occasionally brought out of the yard of the factory, and bowled a few yards about the beautiful roads in its vicinity (the Regent's park). Such events, occurring as they did, when there was "no war, but few murders, and parliament up," were a positive treasure to the newspaper press: hence the columns of the latter were swelled with absurd and puffing accounts of "Mr. Gurney's celebrated invention," and nearly all the world were taught to believe that the important application of steam to locomotion originated with Mr. Gurney. To show that such notions -e ill-founded, we shall place the exact facts, as we have hitherto done, before -ader, who will judge for himself.

The first patent granted to this gentleman was of the before-mentioned date, and was entitled "a new invented apparatus for propelling carriages on common roads or railways." The specification, which was enrolled in November following, is thus reported in the *London Journal of Arts and Sciences*, Vol. XIII.

"The mode of propelling carriages on roads and railways, proposed by the patentee, is by the agency of moving legs, or crutches, striking out under the carriage, the lower ends of which legs are intended to bear against the ground as a resistance, and, being forced backwards by the power of machinery, cause the carriage to move forward in the opposite direction. Similar contrivances to this, have been repeatedly suggested. The patentee, therefore, is to be considered as merely adopting this plan as one that he considers most convenient; and claims as his invention *simply the guide rollers* attached to the legs, upon which the carriage moves forward. The annexed figure represents the side of the carriage running upon ordinary wheels, with the steam-engine by which its propelling legs and other mechanism are to be moved; *a a* is the perch or main-beam of the carriage; *b* the working cylinder of the steam-engine, which in this instance lies nearly horizontal, and is supported in standards upon pivots; *c* is the piston rod of the engine, with a small guide roller running upon the stationary block *d*. The piston rod is attached by a joint to the vibrating lever *e*, from which lever a chain extends over small pullies, let into the



block *d*, and its ends are made fast to the other vibrating lever *f*; consequently these two levers acquire reciprocating motions from the action of the piston rod. At the extremity of the crane's neck *g*, the two oscillating levers *h h* are suspended, and these being respectively attached by connecting rods *i i* to the levers *e* and *f*, move simultaneously with the last-mentioned levers as the piston of the engine works to and fro. The lower ends of the levers *h h* are attached by joints to the horizontal rods *k l*, and these rods are connected to the sliding blocks which move the legs or crutches *m n*. The horizontal rods *k l*, and also the blocks which carry the legs, slide along in rebated grooves, formed in the under side of the perch *a*, which grooves are represented by dots, and a portion of the side of the perch is removed in the figure, to show one of the blocks *o* with its rollers within. The block *o* has small vertical wheels, or anti-friction rollers, by which it is enabled to run freely along the rebate or ledge of the groove; it has also small horizontal rollers, to prevent the block from rubbing against the sides of the groove. In the under side of each of the blocks, a pin *p* is fixed, which is intended to pass through the top of the legs *m* or *n*, and a small helical spring is placed upon the pin, and secured by a screw nut, for the purpose keeping up the top of the leg against the under side of the perch, but affording it some degree of play. By the action of the steam-engine, an

other mechanism connected thereto, the blocks *o* are made to slide reciprocally to and fro, along the grooves of the perch, in the manner above described; and supposing one of the legs or crutches to be brought into the situation of *m*, the foot will take hold of the ground, and remain stationary, while the force of the machinery pressing against it, will cause the carriage to slide forward, and the leg *m* to assume the situation of *n*; while *n* will be advanced into the situation of *m*, and *vice versâ*. Thus by the reciprocating movements of the machinery, the carriage will be progressively impelled forward by the crutches or legs. In order to turn the carriage round corners or angles in the road, the axle of the hinder wheels is made to move round horizontally, upon a central pin, by means of a strap or other contrivance applied at *q*. By this strap and a suitable handle or lever, the conductor guides the course of the carriage in a straight or curved direction. The mechanism by which these blocks and legs are to be moved, may be varied in several ways; for instance, in place of the levers above described, endless chains or cords may be employed, passed over pullies, and attached to the blocks instead of the rods *k l*. Other parts of the apparatus may likewise be varied in their detail, without affecting the principle."

The patentee sets out the particulars of his invention in the following words: "I claim the use of a roller or rollers, wheel or wheels, to the upper ends of my said propellers, re-acting against a straight and smooth rail or plane affixed under and being a part of the carriage, such rail or plane being parallel, or nearly so, to the soles or bottoms of the carriage-wheels, whereby the carriage itself is enabled to be rolled over the upper ends of the said propellers, crutches, or feet, by the mechanical power employed."

By this claim the patentee sums up the entire of his invention, and it consists of "a roller" applied to the invention of William Brunton, which had many years before been found to be useless. It is still more remarkable, that even the very "roller" or "rollers" were employed by Brunton in one of the modifications of his machine, as exhibited in *Fig.* 4 of the specification, and given in Vol. XL. of the *Repertory of Arts*.

We ought not to omit to state, that Mr. Gurney took out a patent at the same momentous period as the former, for a steam generating apparatus, which is faithfully described and illustrated by figures in the 13th vol. of the *London Journal of Arts*. It consists of two different modifications; one of them showing a boiler made of tubes bent into the form of the figure 8; and the other exhibits in its cross section a circle surmounted by two crescent-shaped chambers. We shall only notice those points which are claimed by the patentee as peculiar to his invention. The *first* is, "the employment of wire-gauze to assist in conducting the heat." This was previously recommended in all the scientific periodicals published about that period; but its obvious inapplicability to high-pressure boilers, caused the practical men of the time to leave it to the philosophical experimenters from whom it originated; and Mr. Gurney soon found himself compelled to get rid of this *original* part of his invention. The *second* point is, "the formation of a boiler of tubes bent in peculiar curves." A reference to the specification will show that the meandering of the patentee's tubes causes them to describe *every* variety of curve; consequently, whatever bend or twist a boiler-maker may choose to give his tubes, must be an invasion of "Gurney's principle!" *Third*, "the forming of partitions between plates, to form distinct chambers." This refers to a miserable, absurd, and useless imitation of James's cylindrical boiler of tubes! *Fourth*, "separating the steam from the boiler in a vessel placed contiguous." This boasted improvement of the "separators" consists in placing a steam reservoir in a cold instead of a hot situation! *Fifth*, "increasing the intensity of the furnace, and consuming the smoke by means of a blowing apparatus." For the effrontery of this claim it would be difficult to find a parallel. *Sixth*, "cleaning the inner surface of the boiler from incrustation by a chemical solvent." What! may none of his Majesty's lieges but Mr. Gurney employ the usual chemical solvents to dissolve a well-known substance, wherever they may have occasion to do so? Experienced men will bear us out in the observation, that such processes as are here re-invented, were long before exploded as worse than useless. On this interesting

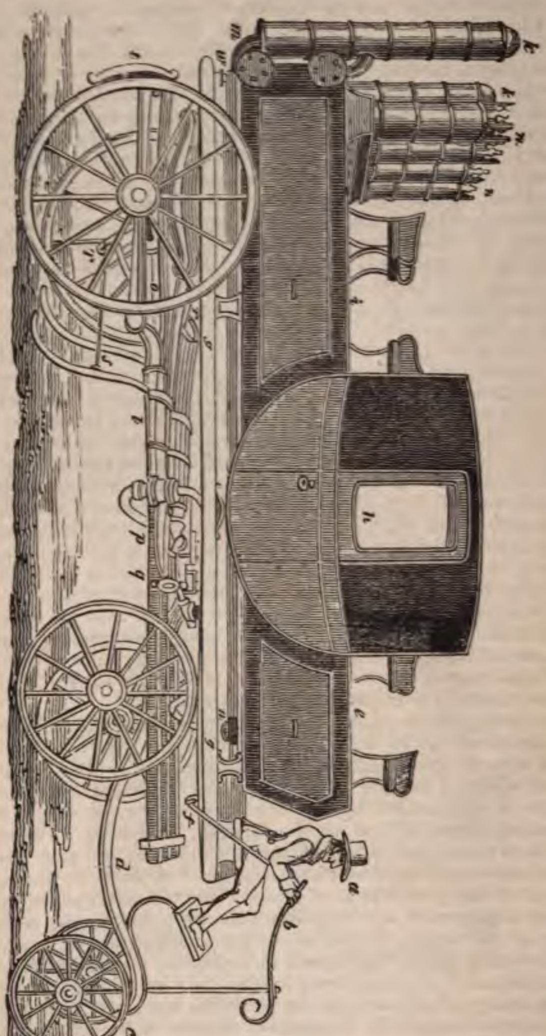
point we are amusingly informed by Dr. Lardner (*Treatise*, p. 255), "This method *was perfectly effectual;* and although its practical application was found to be attended with difficulty in the hands of common workmen, Mr. Gurney was persuaded to adhere to it by the late Dr. Wollaston, until experience proved the *impossibility of getting it effectually performed*, under the circumstances in which boilers are commonly used. Mr. Gurney then adopted a method of removing it by mechanical means. Opposite the mouths of the tubes, on the other side of the cylinders, are placed a number of holes, which, when the boiler is in use, are stopped by pieces of metal screwed into them. When the tubes require to be cleaned, these stoppers are removed, and an iron scraper is introduced through the holes into the tubes, which, being passed backwards and forwards, removes the deposit." This extract proves that Mr. Gurney not only abandoned his "tubes bent into peculiar curves," but likewise the "chemical solvent," which constituted his second and sixth claims. The *seventh* claim is for "an apparatus for regularly supplying the boiler with water," which was to be done by the familiar yet exploded mode of working simultaneously by a connecting rod, two cocks situated on the opposite ends of a water reservoir.

Having thus waded through, as quickly as possible, the *materia* as well as the *medica* of this "happy series of inventions," as they were denominated by a celebrated writer in the *Times* Newspaper, it is natural to inquire what became of them. Hitherto *we* have never met with, nor ever heard of, a single contrivance of Mr. Gurney's that was ever brought into permanent use, or had the slightest effect in advancing or improving the art of steam locomotion. It is unquestionable that many steam-carriages were built under his orders; but so have many more been built, before and afterwards, by the expenditure of less money. We have seen what Mr. Gurney has claimed for himself in his specifications; that most of them were of too puerile and absurd a character to deserve even a trial; and that the remainder were notoriously long before his time publicly in use. Surely a man who could descend to such gross quackery would not have omitted to claim something really beneficial in locomotion, had he invented it. The inference is unavoidable,—that Mr. Gurney had no more to do with the *invention* of steam-carriages, than he had with the building of St. Paul's Cathedral. After the expenditure of many thousands of pounds, he brought out one of his manufacture, towards the close, we believe, of the year 1827. We shall annex a popular description of this carriage, which is extracted from a weekly journal published at that time.

"The carriage is constructed for accommodating six inside and fifteen outside passengers, independently of the guide, who is also the engineer. In front of the coach is a very capacious boot, while behind, that which assumes the appearance of a boot, is the case for the boiler and the furnace, from which no inconvenience is experienced by the outside passenger, although, in cold weather, a certain degree of heat may be obtained, if required. The length of the vehicle, from end to end, is 15 feet, and, with the pole and pilot wheels, 20 feet. The diameter of the hind wheels is 5 feet; of the front wheels, 3 feet 9 inches; and of the pilot wheels, 3 feet. There is a treble perch, by which the machinery is supported, and beneath which two propellers, in going up a hill, may be set in motion, somewhat similar to the action of a horse's legs under similar circumstances, which assist in forcing the carriage to the summit.

"In descending a hill, there is a break fixed on the hind wheel, to increase the friction; but, independently of this, the guide has the power of lessening the force of the steam to any extent, by means of the lever at his right hand, which operates upon the *throttle valve*, and by which he may stop the action of the steam altogether, and effect a counter vacuum in the cylinders. By this means also he regulates the rate of progress on the road. There is another lever by which he can stop the vehicle *instanter*, and in a moment reverse the motion of the wheels, so as to prevent accident, as is the practice with the paddles of steam-vesssels. The duty of the guide, who sits in front, is to keep the vehicle in its proper course, which he does by means of the pilot wheels acting upon the pole.

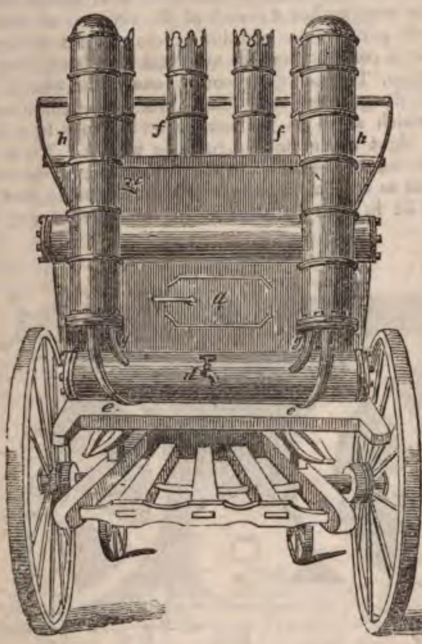
"The total weight of the carriage and all its apparatus is estimated at one and a half ton, and its wear and tear of the road, as compared with a carriage



drawn by four horses, as one is to six. The engine has a twelve-horse power. ay be increased to sixteen : the actual power in use, except in ascending is eight horses.

ig. 1 gives a side view of the machine; *a* the guide and engineer, to

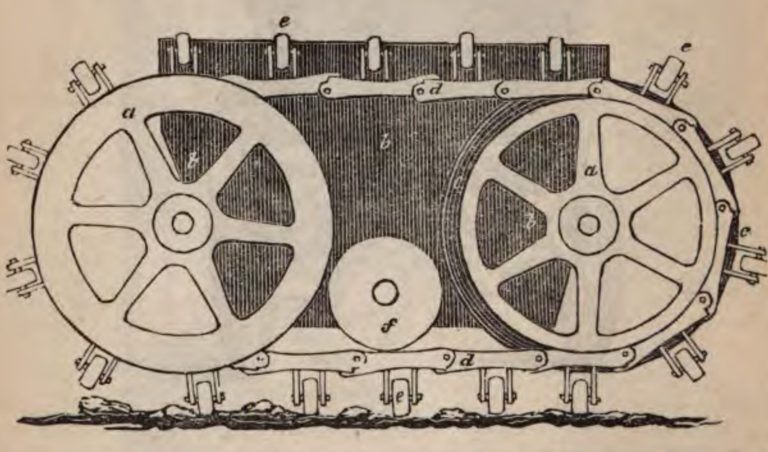
whom the whole management of the machinery and conduct of the carriage is entrusted. Besides this man, a guard will be employed, whose duty it will be to look after the luggage and passengers; *b* the handle, which guides the pole and pilot wheels; *c* the pilot wheels; *d* the pole; *e* the fore boot, for luggage; *f* the throttle valve of the main steam pipe, which, by means of the handle, is opened or closed at pleasure, the power of the steam and the progress of the carriage being thereby regulated, from one to ten or twenty miles per hour; *g* the tank for water, running from end to end, and the full breadth of the carriage; it will contain sixty gallons of water; *h* the carriage, painted claret colour, and lined with cloth of the same hue, capable of holding six inside and twelve outside passengers; *i* the hind boot, containing the boiler and furnace; it is encased with sheet iron, and between the pipes the coke and charcoal are put, the front being closed in the ordinary way (as seen in *Fig.* 2), with an iron door. The pipes extend from the cylindrical reservoir of water at the bottom, to the cylindrical chamber for steam at the top, forming a succession of lines something like a horse-shoe turned edgeways. The steam enters the 'separators' through large pipes, and is thence conducted to its proper destination; *k k* separators, in which the steam is separated from the water, the water descending



and returning to the boiler, while the steam ascends and is forced into the steam pipes of the engine; *l* the pump by which the water is pumped from the tank, by means of a flexible hose, to the reservoir communicating with the boiler; *m* the main steam pipe descending from the 'separators,' and proceeding in a direct line under the body of the coach to the 'throttle valve,' and thence, under the tank, to the cylinders; *n n* flues of the furnace, four in number; *o* the perches, of which there are three, conjoined, to support the machinery; *p* the cylinders—

there is one between each perch; *q* valve motion, admitting steam alternately to each side of the pistons; *r* cranks operating on the axle; at the ends of the axle are ratchets which, as the axle turns round, catch projecting pieces of iron on the boxes of the wheels, and give them the rotatory motion—the hind wheels only are thus operated upon; *s* propellers, used as the carriage ascends a hill; *t* the drag, which is applied to increase the friction on the wheel in going down a hill; this is also assisted by diminishing the pressure of the steam, or, if necessary, inverting the motion of the wheels; *u* the clutch, by which the wheel is sent round; *v* the safety valve, which regulates the proper pressure of the steam in the pipe; *w* the orifice for filling the tank; this is done by means of a flexible hose and a funnel, and occupies but a few seconds. *Fig.* 2 exhibits a back view of the carriage, and the perches that support the machinery, not here introduced; *a* the furnace door; *c* gauge cock; *d* blow cock; *e e* steam pipes; *f f* flues to furnace; *g g* the pipes through which the water is propelled from the separators *h h* into the boiler.

In October, 1825, Sir George Cayley, of Brompton, in Yorkshire, obtained letters patent for a locomotive apparatus on the same principle as Mr. Barry's, described at page 77, but somewhat differently applied. An elevation of this machine is given in the following cut; *a a* represent a side view of the fore and hind running wheels of the carriage, the axletrees of which are made fast to the inclined ends of the waggon box *b;* each of the two pair of wheels have deep grooves *c c* in their peripheries, and into these a stout endless chain *d d* is passed around, so as to connect the fore and hind wheels together on the opposite side of the carriage. To show the groove *c*, one of the wheels is represented with one of the side flanges removed. Each link of the chain carries two perpendicular arms, which serve as the carrier or bearings to a small roller *e e*, which revolves at right angles to the running wheels. These rollers, which form a continuous series on both sides of the carriage, come successively in contact with the ground as the machine is moved in its course, and step over the obstacles that may lie in their path. But in the case of any of the rollers



alighting on a prominent stone, which might cause an injurious strain upon the machine, a solid wheel or roller *f* is fixed midway between the wheels on each side of the carriage, which receive and are capable of sustaining the pressure. In order that the carriage may be moved sideways, the rollers are placed at right angles with the running wheels.

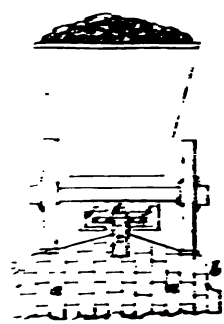
The patentee has introduced into his specification some ingenious contrivances for keeping the wheels in a straight path upon unlevel surfaces; but as these

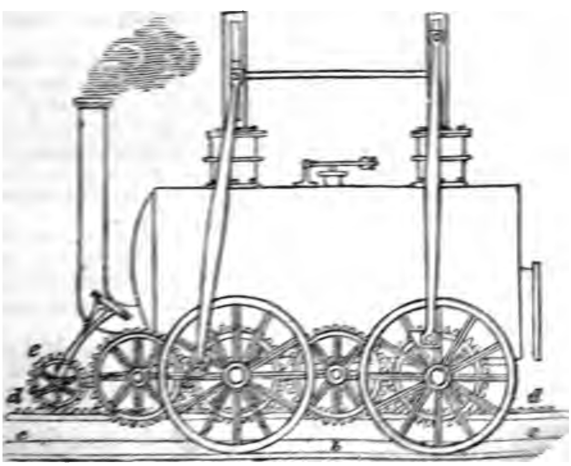
do not possess a very practical character, we must refer the reader to the specification for the particulars of them.

In the early part of this article are given some plans for the employment of toothed racks to railways, to enable a carriage, provided with a toothed wheel, taking into the teeth of the rack, to obtain sufficient resistance to ascend steep inclined planes: but the former were subject to the disadvantage of a strain or twist, the rack in them being placed on one *side* of the way. To obviate this defect appears to have been the object of Mr. Josiah Easton, who took out a patent, dated the 13th October, 1825, for "certain improvements in locomotive or steam carriages, and also in the manner of constructing the roads or ways for the same to travel on." The following brief description of this invention is given in the *London Journal of Arts*, Vol. XI.:—"These improvements consist, first, in forming a line of road, with a raised part along the middle, upon which a rack, or toothed bar of iron is placed; and secondly, in adapting a toothed wheel to the steam carriage, which shall take into the said rack, and being actuated by the rotatory power of the steam-engine, shall thereby cause the carriage to be impelled forward upon the line of railroad, and the trams or other waggons after it."

In the subjoined cuts, *Fig.* 1 exhibits a transverse section of the railroad, with the end view of a waggon upon it. *Fig.* 2 is a side elevation of the same, showing the manner in which the carriage is driven; *a a* is the road formed of masonry, the parts *b b*, on which the running wheels travel, being on a lower plane than the central part *c* of the road, whereon the rack *d* is situated. The steam-engine, and other machinery appertaining to the locomotive, are constructed in the usual way; the only novelty in the carriage is the toothed wheel *e*, which takes into the rack *d*, fixed along the centre of the road; and this toothed wheel being made to turn through the agency of a train of wheels actuated by the steam-engine, the carriage is thereby propelled, and the waggons drawn after it. In order to keep the carriage-s in their track upon the road, two guide rollers *f f* are placed under the carriage, which run against the side of the central rib, and this prevents them from moving out of their course.

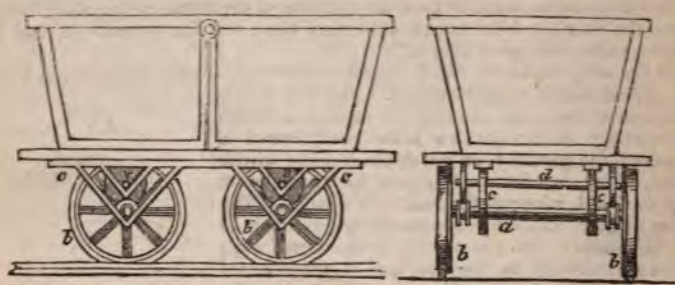
Fig. 1.





The chief resistance to the motion of carriages upon railways arising, as has before been explained, from the friction of the axles, many attempts have been made to reduce it, by the introduction of anti-friction rollers, variously disposed, the design being to convert the rubbing, or sliding, into a rolling action: but the generality of the contrivances for this purpose have had no other consequence than the removal of the friction from one part to another, and of weakening or encumbering the general structure by an unnecessary multiplicity of parts. How far these observations may apply to the invention of Mr. Brandreth, of Liverpool, patented in November 1825, we will leave the reader to consider. *Fig.* 1 exhibits a side elevation, and *Fig.* 2 an end elevation, of a railway

Fig. 1 *Fig.* 2.



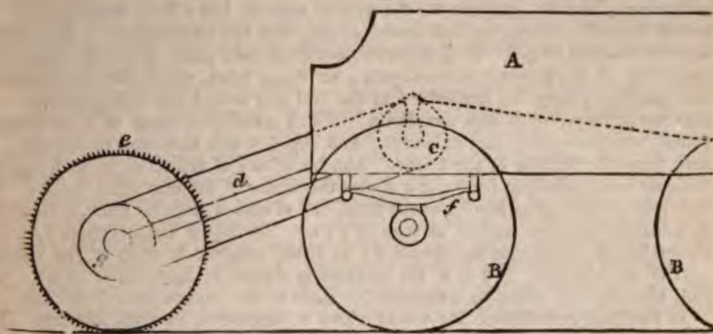
waggon, to which Mr. Brandreth's patent is applied. *a a* are the axes of the running wheels *b b*, turning in bushes, and suspended in an angular iron framing *c c*; at *d* is another axis above, carrying near its extremities anti-friction rollers *e e*, the peripheries of which roll in contact with a grooved bearing on the lower axis, by the revolving motion of the latter. The drawing, *Fig.* 1. is intended to show a coal waggon, divided into two receptacles, and connected together by a hinge joint. They are provided with loose bottoms, so that when they are brought on to the stage, whereon or through which the coals are shot, they may be readily discharged by the withdrawal of a bolt.

In November 1825, Messrs. John and Samuel Seaward, of the City Canal, London, obtained a patent under which their claim was for "the propelling locomotive engines, vehicles, and other carriages, by means of a wheel or wheels connected either by a swinging frame or frames to the crank shaft of a steam-engine, or other moving power, or working in circular grooves, so that it, or they, may rise or fall, to connect themselves to the roughness or unevenness of the ground, but supporting no part of the weight of the said engine, such weight being entirely supported upon separate wheels."

A locomotive engine at *a* was placed on two pair of wheels *b*; *c* is the crank shaft of a steam-engine within the body of the machine; to the shaft *c* is attached the swinging frame *d*, with a propeller *e* turning on its axis *g*, at the vibrating end of the swinging frame. The steam-engine was upon the springs *f*, so that the machine might travel upon rough roads.

The extraordinary friction and resistance between the flanges of the wheels of a locomotive engine, and the edges of the rails, in passing round curves, unless the radii be very considerable, struck forcibly the attention of Mr. Robert Stephenson, who succeeded in devising a very ingenious mode of obviating it, which he patented on the 23d of January, 1826. The following description of it is extracted from the *Register of Arts*:—"Instead of two wheels, fixed as usual to the extremities of one axletree, Mr. Stephenson's plan is to have a

separate axletree to each wheel, so that they may revolve independently, and at different velocities, as circumstances may require. The outer wheels of a four-



wheeled carriage (or those which are on the longest of two curved parallel lines) will therefore be at liberty to run faster than those on the inner side (or on the shortest line), thereby preventing that sliding motion, and its destructive effects, when passing round curves, which, on extensive lines of road, are generally found unavoidable.

Mr. Stephenson's improvements in axles likewise embrace another object of more momentous importance, that of providing a remedy for the unequal strain to which a carriage is subjected in passing over those parts of a railway that

Fig. 1.

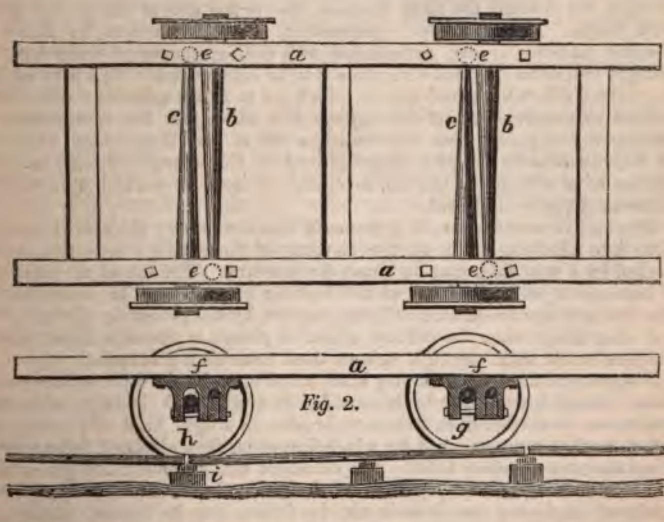


Fig. 2.

lie hollow, or below the level of the contiguous parts, owing to the sleepers or other supports having sunk or given way, which causes the carriage and its

slipping round. A second method devised by the patentees, of preventing this effect, has, we believe, been patented more than once. This is to fasten upon the tire a series of flat springing plates, each of them forming a tangent to the circumference: so that, as the wheels roll forward, each plate shall be bent against the tire, and recover its tangential position as it leaves the ground in its revolution. By this arrangement it was considered, that if there was any disposition to slip, the increased bearing surface of the plate, and the resistance of its farthest edge, would infallibly prevent it. Mr. Neville does not explain how he would prevent the road-stuff from getting between the plates and the tire, and forcing them off the latter, or at the least bending them so as to change the circular periphery into an irregular polygon.

For propelling the carriage, Mr. Neville proposes to use an horizontal vibrating cylinder, to give motion direct to the crank axis, by means of the compound motion of the piston rod, as invented by Trevithick; the motion to the running wheels to be communicated through geer of different velocities; the boiler and blowing apparatus to be according to former patents of 1823 and 1826.

It is perhaps impossible entirely to prevent the sinking of certain parts of a railroad, so as to cause by such inequality of level the carriages travelling upon it occasionally to bear upon only three wheels, rendering them thereby liable to severe strains, and sometimes to breakage, as well as flying off the rails. At page 109, we have described Mr. Stevenson's axletrees designed to remedy this evil, and we have now to notice a patent granted to Mr. William Chapman, of Newcastle-upon-Tyne, for a similar object, and dated the 14th of August, 1827. The improvements for this purpose are performed by detaching the axles from the bottom of the waggon, and connecting them together at the same distance from each other as before, by two bars of wood or iron of that length, fixed on the turned parts near the wheels which bars have cavities at each end, opening downwards, properly fitted for the revolution of the axles, and extending below them a sufficient distance to admit of the introduction of a greasing apparatus, that will presently be described: these bars may be made elastic, so as to have the effect of springs, if this be preferred. The waggon is supported above these bars by a gudgeon or axle that passes across the middle of its bottom underneath, and rests on the middles of the two bars. This gudgeon is fastened to the side pieces of the frame-work of the waggon's bottom by staples at each end, while it is secured to the bars by sockets or joints, that admit of motion in a vertical, but preclude it in a horizontal direction; and, at the same time, vertical bolts descend from the waggon's bottom frame, below their sustaining bars, near ends, and outside them, so as to enclose and secure them better from lateral motion, in passing round curvatures in the rails, admitting them at the same time to move up and down with facility. To strengthen the lower frame of the waggon, and give more support to its extremities, upright bars are fixed directly over the central gudgeon at each of its sides, from the tops of which diagonal rods descend obliquely in opposite directions to the terminations of the side pieces of the frame.

By this arrangement of parts all resistance to the vertical motion of the wheels is removed, by the flexibility of the joints of this secondary frame beneath the waggon, so that the load will be supported equally by each of the wheels when not exceeding the usual number of four, in any inequality of the level of the rails that is not beyond all bounds; though should six or more wheels be employed with one waggon, a more complicated frame-work would be necessary to produce the same equality of support.

The greasing apparatus before mentioned, that is directed to be placed beneath the revolving parts of the axles, consists of a horizontal balance, lever-jointed at its centre of motion to the middle of one of the descending sides of the axle beds at the ends of the sustaining bars, the outward arm of which lever [illegible] a sliding weight attached to it, the shifting of which farther from or nearer [illegible] centre, regulates the degree of pressure with which the other arm is [illegible]d up against the under part of the axle; above this latter arm a piece of [illegible] is placed, that is excavated at its upper surface so as to fit the lower part [illegible] axle, and has projecting parts at its ends that slide up and down in

grooves at the sides of the lower part of the axle, and has projecting parts at its ends that slide up and down in grooves at the side of the lower parts of the axle bends, which retain it in its place while being pressed upwards by the means mentioned; and a double piece of woollen cloth, or other substance proper for holding grease or oil, and well saturated with either, being placed between this last mentioned piece of metal, and the lower side of the axle, the pressure caused by the weight on the opposite arm of the lever will make it closely apply to the axle, so as to keep the latter constantly well greased, independent of any minute care of the attendants.

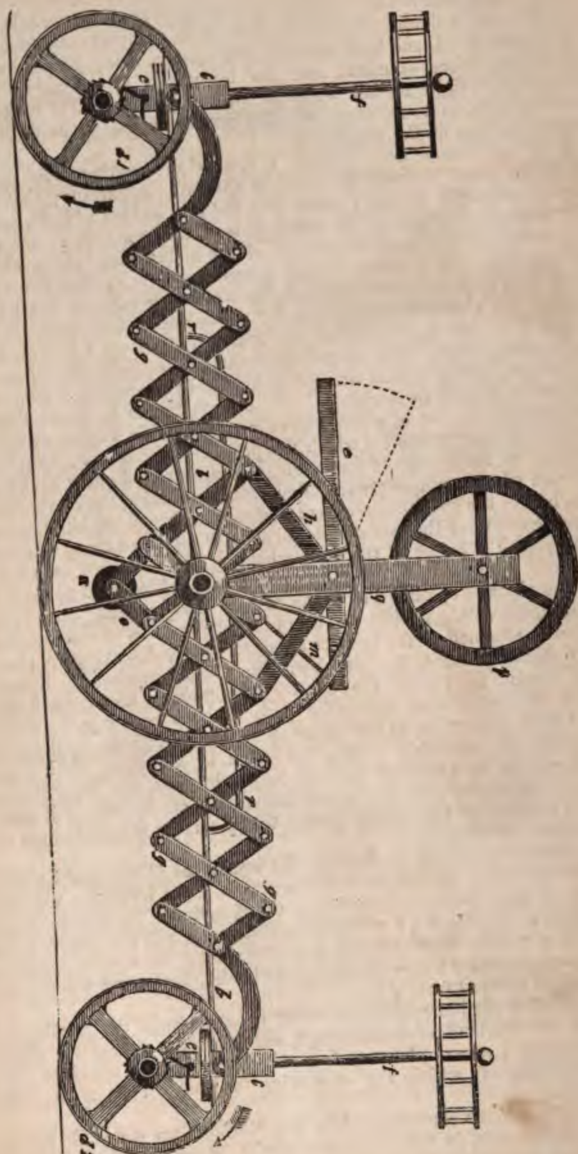
A spring may also be used similarly to the weight mentioned, for pressing the hollow metal piece towards the axle in the latter apparatus; that which the patentee recommends for this purpose, is a flat thin lamina of steel, placed horizontally through apertures in the lower parts of the axle beds in the sustaining bars, so as to press against the bottom of the hollow metal piece with a force, that is regulated by a screw, which passes upwards against one of its ends through a hole underneath the apertures in which this latter is inserted.

Amongst the singular propositions for producing a locomotive action, was that invented by Mr. T. S. Holland, for which he took out a patent, dated the 19th December, 1827. The invention consists in the application of an arrangement of levers, similar to that commonly known by the name of *lazy-tongs*, for the purpose of propelling carriages. The objects appear to be, to derive from the reciprocating motion of a short lever a considerable degree of speed, and to obtain an abutment, against which the propellers should act horizontally, in the direction of the motion of the carriage, instead of obliquely to that motion, as is the case when carriages are impelled by levers striking the earth. The drawings attached to the specification seem designed rather to explain the principle, than to represent what the patentee would deem an eligible form of its application. (See next page.) *a* is one of the main wheels of the carriage; attached to the axle is a long guide-rod *b b*, extending before and behind, and passing through holes in the blocks *c c*, placed over the beds of the propelling wheels *d d*; *e e* are double palls, acting against two sets of ratchet wheels on the boxes of *d d*; *f f* standards attached to the beds or axles of *d d*, and serving to place them in any required position, by means of the wheels attached to them; *g g* a series of expanding levers, the central pair playing upon the main axle; *h h* a pair of longer bars, connected with the two bars *g g*, at their lower ends, and with each other, at the upper ends, by a bar, shown by dots, between two uprights; the fulcrum *l*, a lever connected by a rope *m*, with a counterweight, supported by two short bars *o o*, suspended from the lower bars *g g*; *p* a fly-wheel, connected with the upper extremities of the bars *h h*, which rise and fall in grooves, in the upright post *q*, the fly serving to equalize the motion; *r* the platform or carriage.

The action is as follows:—Suppose the apparatus in the position shown in the engraving; allow the weight *n* to descend, and the levers *g g* will collapse; but as the wheels *d d* can only revolve in the direction of the arrow, on account of the palls *e e*, the wheel *d* 1 will remain stationary, and the wheel *d*, and the main wheel *a*, will be drawn towards *d* 1. On raising the weight, the levers *g g* will be extended, and *g* 2 now becoming stationary, the centre wheel *a* and *d* 1 will be pushed forward from *d* 2.

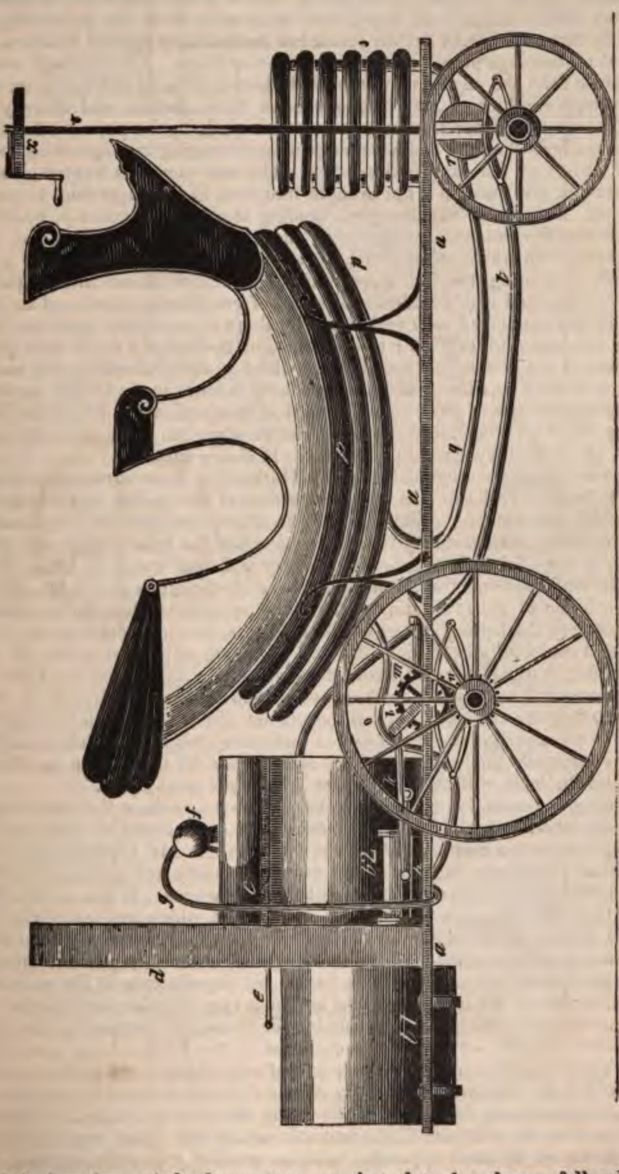
Two days after the last-mentioned contrivance obtained the privilege of the Great Seal, Dr. Harland, of Scarborough, also passed a patent for what may be denominated a steam phaeton, from the figure of the carriage given in the specification, of which the engraving on page 115, is a sufficient resemblance.

"The improvements contemplated by Dr. Harland, are stated, in his specification, to consist, first, in the construction of a boiler, by which a very large surface of the fire and flue will be placed in contact with the water, for the rapid production of steam; secondly, in the employment of a condenser, which, by its extensive surface, shall condense the steam by the influence of the atmosphere; thirdly, in a mode of fixing the working cylinder, without allowing it to vibrate in hollow arms or trunnions.



'*a a* represents the bed of the carriage; *b* 1 and *b* 2 the boiler, composed *of two double* cylinders, *b* 1 containing the fire-grate and ash-pit, and the cylin*der b* 2 containing another double cylinder; so that there are, in fact, three

double cylinders, each full of water, and communicating with the reservoir and steam chamber *c*, which must be of sufficient capacity to keep the boilers sup-



plied during the period of one stage, so that they be always full: *d* is the chimney; *e* a damper, by which the boiler *b* 2 may occasionally be withdrawn

in part from the action of the fire; *f* is a spherical vessel on the top of the reservoir, the object of which is to prevent the water thrown up with the steam being driven with the steam into the pipe *g*, which conveys it to the working cylinder *h;* this cylinder is secured horizontally to the bed of the carriage, and having guides extending from end to end, in which side-rods, attached to the cross on the piston rod, move, and carry with them the connecting rod *k*, which turns the crank *l;* this crank has on its axis a toothed wheel *m*, and revolves on bearings placed on the bed of the carriage. The carriage receives its impulse from the engine upon the hind wheels; the axis of these carry small tooth-wheels *n*, which gearing into *m*, receive their motion, and thereby turn round the running wheels. Arrangements are made by the patentee for throwing the toothed-wheels *m* and *n* out of gear, and bringing into operation another pair of wheels on the same axles, when additional power is wanted; but the apparatus for this purpose is not brought into view in the engraving, to prevent confusion. At *o* is an eduction pipe, leading to a series of tubes *p*, which are denominated the condensing chambers, and may be used, either alone or in conjunction with water, to condense the steam on leaving the cylinder; *q*, is a pipe for conducting the hot water and uncondensed steam into a globular vessel *r*, connected with an additional series of condensing pipes *s*, of an annular form, and connected with each other by short pipes; *t*, is a pipe for returning the condensed water from *r* to the boiler, by the aid of a small force pump; *v* is a forked rod attached to the steering wheel *x*, and descending into holes in the arms of the fore wheels, and having liberty to move up and down, according with the inequalities of the road; the vertical standard, upon which the upper steering wheel *x* is fixed, also forms the centre of motion to the arms of the fore wheels, and is thereby made to direct them in their course.

"The advantages contemplated by Dr. Harland in these arrangements, will, we fear, not be realised. In the construction of the boiler, there is nothing upon which we can congratulate him. The attempt to condense the steam has been long since abandoned by those who have had the most experience on the subject; it is evidently impracticable to carry sufficient water to effect even a tolerable condensation; the conducting power of the air is much too slow for the abstraction of the heat, and it should be considered that the air which is liberated from the boiling water, would require a pump to draw it off, which would add complexity to the machinery. With regard to the mode of fixing the cylinder, it differs but little from that adopted by Mr. Gurney. The mode of communicating the power to the wheels is extremely defective, for it will be observed, that the *driving* toothed-wheels *m* are (in effect) mounted upon the springs of the carriage, above the *driven* toothed-wheels *n*, by which means they will be continually liable to be thrown out of gear by the motion of the carriage, and the teeth will be liable to break from the same cause."

Pursuing our narration chronologically, we must now draw the reader's attention to the labours of Mr. Walter Hancock, who commenced his career of constructing locomotive carriages about the same time as Mr. Gurney; but whose mechanical arrangements possess far more originality and genuine merit, and have, in consequence, been attended with greater success. It was at this period (1827) that Mr. Hancock took out his first patent, which was for a light high-pressure boiler, designed for locomotive purposes; the description of this we shall, however, defer, until we have made a retrospect of his previous labours.

This gentleman, we are informed, began his experiments in the year 1824, with an engine of his own invention, and of a very singular construction; but which he imagined was peculiarly suitable for locomotive purposes. The engine had neither cylinder nor piston, but consisted of two flexible bags, made of his brother's *patent artificial leather*, composed of caoutchouc, combined with several layers of linen. Communications, by means of a four-way cock, admitted the steam alternately into these bags, which being attached to a suitable frame with a slide motion, the alternate filling and exhausting took place, and the reciprocation produced by their expansion and contraction was communicated to a crank, which converted it into circular motion. The caoutchouc was found to answer for a short time, but the heat soon rendered the bags permeable, and

[illegible]

... by Mr. Alexander Gordon.
... the fire-place, the fuel being
... fire-place and the ash-pit b; the
... that the blast from the revolving
... the fire. The fire-place is also
... eye-holes, through which the firemen
... can view the state of the fire
... through the feeding hopper q. On the
... of them being always shut, to prevent
... hopper, when the coke is added to the
... of which there are two, through r, and
... placed under the control of the
... alternating vertical motion of the pis-
... from the parallel motion t to the crank
... upon e, by the connecting-rod r. Only
... be shown in this "section." Two shives
... the crank shaft e, and two also upon the
... round each pair of shives, and conveys
... to the hinder wheels. It is necessary
... always parallel to, and equi-distant
... chains may be in an equal state of
... of two rods, one on each side of the
... a centre, and cause the crank axis e
... describe a larger or smaller segment, with
... which the engines are placed, plays up
... concussions which affect the wheels.
... radius rods are constantly vibrating, but
... suspended upon flexible steel springs.
... water tanks k k: k is a connecting rod, by
... the throttle-valve s, and supply himself
... altogether off, when stopping.
... and two thrown together with the pumps.
... which provide for any concussion on rough
... the axle, and one or other, or both, are fixed
... on the outside of the wheel, and can
... with great facility. The turning of
... is prepared for, by throwing out the off-side
... near side, and the turn round to the near side is
... the near clutch, and throwing in the off-side
... so that a wind-
... and it is only in a short
... and this can be done in
...
... with the
... the waste steam is ... from the engines into the chimney, and
... The passengers are carried in the same manner. Mr. Hancock
... the weight by the dragging of ... a carriage behind.
... carriage are a beautiful exhibition of strength and lightness
... are all wedge-shaped, and where they are fastened
... against each other. Their ... is prevented by
... and ... the nave, and these being ... through,
... in their place. ... he takes in
... and sometimes ..., depending
... the road, consuming more steam when the roads run heavy.
... minutes in getting up the steam, and he does
... this purpose at first starting. The
... the machinery is quite

behind the carriage; and the fore part of the carriage is entirely for the convenience of passengers, being made of greater or less length according to the number of persons. The guide sits in front, at *l*, and steers by means of a wheel, *o*, placed horizontally, as in Mr. Gurney's carriage; with this difference, that instead of the vertical spindle having a pinion at *p*, it is made with a horizontal drum or shive, upon which the middle of a chain is fastened; the ends of the chain are attached to the different ends of the fore-axletree in such manner that one or other of the fore-wheels may be hauled forward to turn the carriage. One important improvement in the guide-motion has been made by Mr. Hancock, which is by means of a friction-strap or band at *p*, passed round a small friction drum; the guide can, by pressing a pedal with his foot, tighten this band on the drum when the carriage does not require to be turned out of the straight course. When the carriage is thus held in its line of direction, the guide's hands may be released from the tiller-wheel, *o*; for the jolting of the wheels over rough pavement or other inequalities of a road, are not sufficient to slip the friction-band. In case of requiring to turn, the guide's foot is either relaxed or taken off the pedal, and the tiller, *o*, worked by his hands. This band is of great importance in many cases, and by it a guide with feeble arms may steer as well as a Hercules. This carriage is capable of carrying sixteen passengers, besides the engineer and guide. The weight of it, inclusive of engines, boilers, coke, and water, but exclusive of attendants and passengers, is about three and a half tons.

The wheel tires are 3½ inches wide. The diameter of hind wheels, 4 feet. The width of tire is not considered by the patentee to be so objectionable in practice as it might be considered. This he accounts for, by the variable nature of the roads; "a broad wheel on gravel is considered to be an advantage; it is however a great disadvantage on a road between wet and dry; but in those latter cases we have always an overplus of power (steam) blowing off at the safety-valve." Blowing off steam, either from the safety-valve or from the engines, creates no nuisance, because it is injected "into the fire in every direction," and so destroyed. The carriage can be turned in little more than ten feet, and stopped in much shorter space than any horse-coach. A metallic band, pressing upon the outer part of the wheel, is applied as a drag or brake when descending hills. In slippery roads, or steep hills, both hind wheels are connected with the engine, in order to increase the adhesion to the road; but in general one driving wheel is found to be sufficient.

"In October, 1832, Mr. Hancock determined to make a trip to Brighton. On Wednesday, October 31, this steam carriage came from Stratford, through the streets of the city, at the different speeds necessary to keep its place behind or before other carriages as occasion required, and took up its quarters on Blackfriars Road, to prepare for the following day's trial. Accompanied by a scientific friend, a distinguished officer in the navy, I joined Mr. Hancock's friends on the next morning, making eleven passengers in all. We started at the rate of nine miles an hour, and kept this speed until we arrived at Redhill, (where all the coaches at this season require six horses,) which we ascended at the speed of between five and six miles an hour. The bane of the journey was an insufficient supply of coke and water; the water, indeed, we were obliged to suck up with one of Hancock's flexible hose pipes, at such ponds and streams as we could find. These difficulties delayed the completion of the journey (subsequently performed by steam in less than five hours) till next day; but on our return our speed was much increased, and one mile was accomplished up hill, at the speed of seventeen miles per hour."—*Elemental Locomotion*, p. 111.

"Reverting to the history of my carriages," observes Mr. Hancock, "I may remark that the *Infant* was the first steam carriage that ran on a common road for hire, which it commenced in February, 1831, between Stratford and London, and on which duty it continued several weeks in regular performance; but as I had not at this early period practised any person in steering, and my presence being required at home, I was under the necessity of taking it off the road. This carriage was also the first one that steamed through the public streets of the city of London.

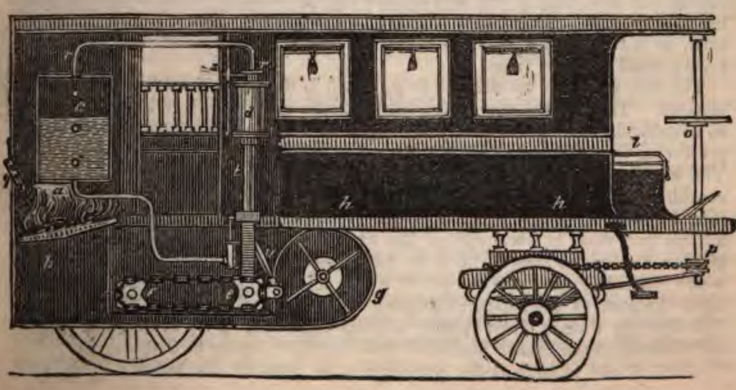
frankly that the carriage worked well; but expressed their decided conviction that it would never answer for a continuance. Others would depreciate its performances, exaggerate its defects, and exult, as it were, in every instance of accidental stoppage. If requiring temporary accommodation, through the failure of some part of the machinery, a circumstance naturally enough of frequent occurrence in this early period of his locomotive career, Mr. Hancock usually experienced the reverse of kind or considerate treatment. Exorbitant charges were made for the most trifling services, and important facilities withheld, which it would have cost nothing to afford. If temporarily detained on the road from the want of water, or from any other cause, he was assailed with hooting, yelling, hissing, and sometimes even with the grossest abuse; waggons, carts, coaches, vans, trucks, horsemen, and pedestrians, pressed so close on the carriage, as sometimes to preclude the possibility of moving; and his situation was often rendered very irksome and irritating; sometimes very hazardous. Undismayed by these untoward circumstances, however, he persevered in his experiments; and as the novelty of such exhibitions wore off, so did the excitement and the opposition which they at first produced.

Becoming convinced from experience that there was a disadvantage in applying the power directly to the crank, as before noticed, Mr. Hancock next placed the engines quite behind, and at the same time altered the form of the carriage, so as to make it more nearly resemble an ordinary horse carriage. Much study and labour were spent upon the various alterations that were suggested and tried from time to time. But the difficulty of keeping the machinery clean, owing to its proximity to the fire-place, as well as to the road, was found in practice to be so strong an objection, that this form of carriage was also abandoned. Nevertheless with this carriage, one point, of the greatest importance in steam travelling, was most satisfactorily determined. The possibility of a steam carriage ascending steep hills had been doubted and questioned by many; and to remove, if possible, all scepticism on the subject, a day was appointed for taking his carriage up Pentonville-hill, which had a rise of 1 in 18 to 20, and a numerous party assembled to witness the experiment. A severe frost succeeding a shower of sleet, had completely glazed the road, so that horses could scarcely keep their footing. The carriage, however, without the aid of propellers, or any other such appendage, ascended the hill at considerable speed, and its summit was attained, while his competitors, with their horses, were yet but a little way from the bottom. Stimulated by the success of such experiments, he remodelled the entire arrangement of the machinery. The trunnion engines were laid aside, and fixed ones substituted; and such other alterations and improvements adopted, as had suggested themselves during actual work upon the road. The carriage, as thus reconstructed, was called, in reference to the infancy of the undertaking, the "INFANT." In this engine, the bulk of the machinery is fixed in the rear of the part appropriated to the passengers. There is, first, the boiler, with the fire-place under it. Second, a space between the boiler and passengers, for the engines, and the engineer who accompanies the carriage, whence he has the whole of the machinery within his reach, and open to his view; and is thus enabled, during the progress of the carriage, to lubricate the parts requiring oil—attend to the gauge-cocks, and regulate the supply of water to the boiler, as well as the degree of blast from the blower—to increase or diminish the generation of steam, according to the various states of the road, and the wants of the engines, —and generally to give his immediate attention to any portion of the machinery requiring adjustment. And, third, a pair of inverted fixed engines, working vertically on a crank shaft. The whole is on one framing, supported by four common coach springs, on the axle of each wheel.

On the crank shaft and on the axle of the hind wheels, are fixed indented pulleys, around which an endless chain passes, which communicates the power and rotary motion of the crank shaft to the hind axle, and propelling wheels, and *thereby* effects the progressive motion of the whole carriage. When it is *esired to back* the carriage, the action of the engines is merely reversed, which *n be effected* almost instantly. The advantages realised by the improved

arrangement shown in the *Infant* are numerous. The engines are completely protected from the dirt and dust of the roads; are at all times in sight of the engineer, and every part of them is within his reach. The passengers, engines, boiler, fire-place, &c., are all equally relieved from concussion, by complete suspension on springs, similar to a stage coach; the chains allowing full play to the springs, and a vibrating stay from the crank to the axle preventing the pull of the chains, and securing a uniform distance between the axle and crank shaft. By the employment, too, of a distinct crank shaft, the axletree, which has to carry all the weight, is not only preserved straight, and consequently of the best form to sustain that weight, but it is also relieved from the strain which it has to bear, where it forms both crank and axle, and has to propel the carriage, and carry the weight as well. The *Infant* thus fitted up, was tried in every possible way, during several months, and proved so perfectly efficient, that in all the carriages which Mr. Hancock has since constructed, he has adhered to the same general plan of arrangement, with the exception of some modifications in the details, which more extended experience has suggested. But though the general arrangement of the *Infant* was such as to leave but little occasion for alteration, there were yet several important points that remained to be cleared up, such as the best proportions and size for the chambers of the boiler—the best form for each separate portion of the machinery—the proper position, size, and strength of the various parts, and also the most suitable kind of materials, so as to avoid as much as possible superfluous weight Experiments to ascertain these various points occupied Mr. Hancock till the beginning of the year 1831, so that full six years had elapsed from the commencement of his locomotive pursuits, before the *Infant* was produced in a state somewhat to the satisfaction of his own mind. The trials made during this probationary period, comprise a total of many hundred miles, all made upon the high roads, near London, principally in the vicinity of Stratford; between which place and Whitechapel, vehicles of every description being in constant motion, afforded him an excellent opportunity of obtaining practical experience, under every circumstance of difficulty, in which a steam-carriage might be expected to be placed; and this consideration determined him to give the most frequented road the preference. In February, 1831, he commenced running the *Infant* regularly for hire, on the road between Stratford and London; not, certainly, with an anticipation of profit, but as a means of dissipating any remaining prejudices, and establishing a favourable judgment in the public mind as to the practicability of steam travelling on common roads. Mr. Hancock observes, that it is an undeniable fact, and a source of proud satisfaction to him, that a steam carriage of his construction was *the first* that ever plied for hire on a common road, and that he achieved this triumph single-handed.

In the following engraving is exhibited a sketch of the arrangement of the



first steam carriage that had been seen there; again it ran there in the summer of 1833, as did also the *Autopsy*. The first day the *Automaton* was worked, it took a party to Romford and back, without the smallest repair or alteration being required; the speed was from 10 to 12 miles per hour: this carriage has, within the last fortnight, run twice to Epping, each time with a party desirous of witnessing its performance on that hilly road; it travelled on the ordinary road at 12 to 14 miles, and ascended the hills, which are very steep, at 7 or 8 miles per hour." (We annex a representation of the *Automaton*, extracted from the *Mechanics' Magazine*.)

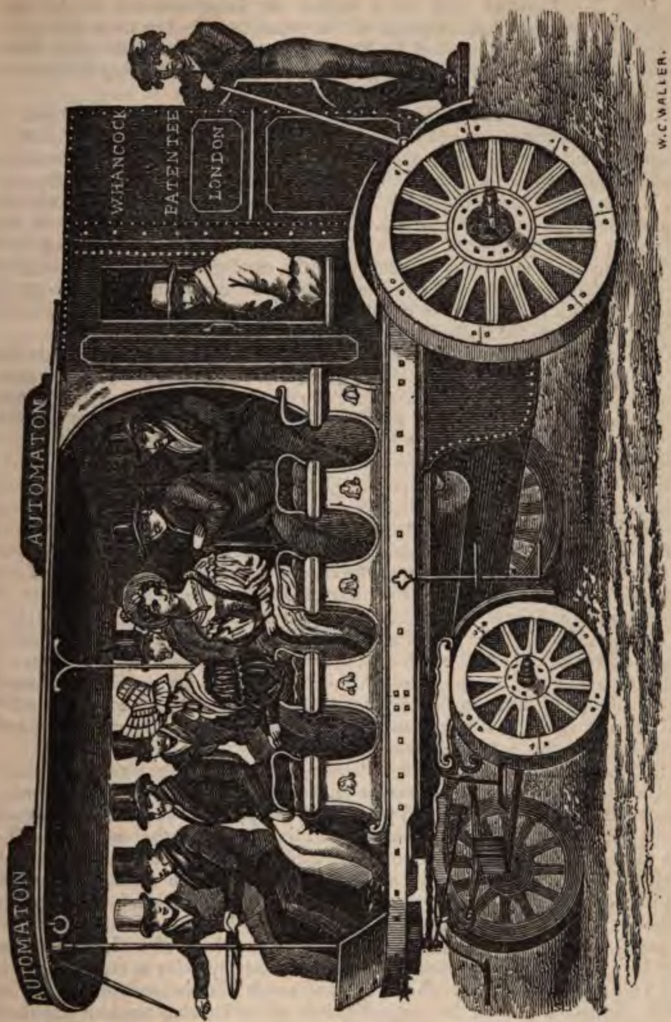
"The carriages have all proved more powerful than I had expected; the first time I was forcibly acquainted with this fact was whilst running for hire in the year 1834. A trifling casualty to the machinery of the *Autopsy* brought it to a stand, and the *Erin* was fetched to its assistance, when it towed the *Autopsy* up Pentonville-hill to the station in the City-road, without any material diminution of its speed, although this, as well as the other carriages, had only been calculated to carry a certain number of passengers, with water and fuel for the trip. The average working speed of all the carriages is from 10 to 12 miles an hour, though they may be pushed far beyond this. The fuel costs about two-pence-halfpenny a mile. The wear and tear is principally confined to the boilers, fireplaces, and wheels; but this is not so great as might be expected; and some of the carriages now running have had their boilers in use upwards of two years; when they are worn out it is only the chambers that require renewing, for my boilers are so constructed that all the main and expensive parts, such as bolts, stays, &c., will last for many years, and wear out several sets of chambers. As to the machinery, the wear and tear appears to be very trifling, as far as the carriages have yet performed; they have, in many respects, actually improved: and even the *Infant*, which has been so many years in action, is in as good condition as ever it was in the original parts of its machinery.

"It may be readily supposed, that in bringing out a novelty of the kind now under consideration, and putting it into actual and effective operation, we have not been without accidents in our career, but are happy to say they have been few, and of trivial amount, with the exception of one, which was that of a workman, who, by a daring of the most imprudent stamp, caused an accident, which, whilst it proved the general safety of my boiler, I regret to say, deprived him of life. This statement was fully borne out to the satisfaction of the coroner and jury.

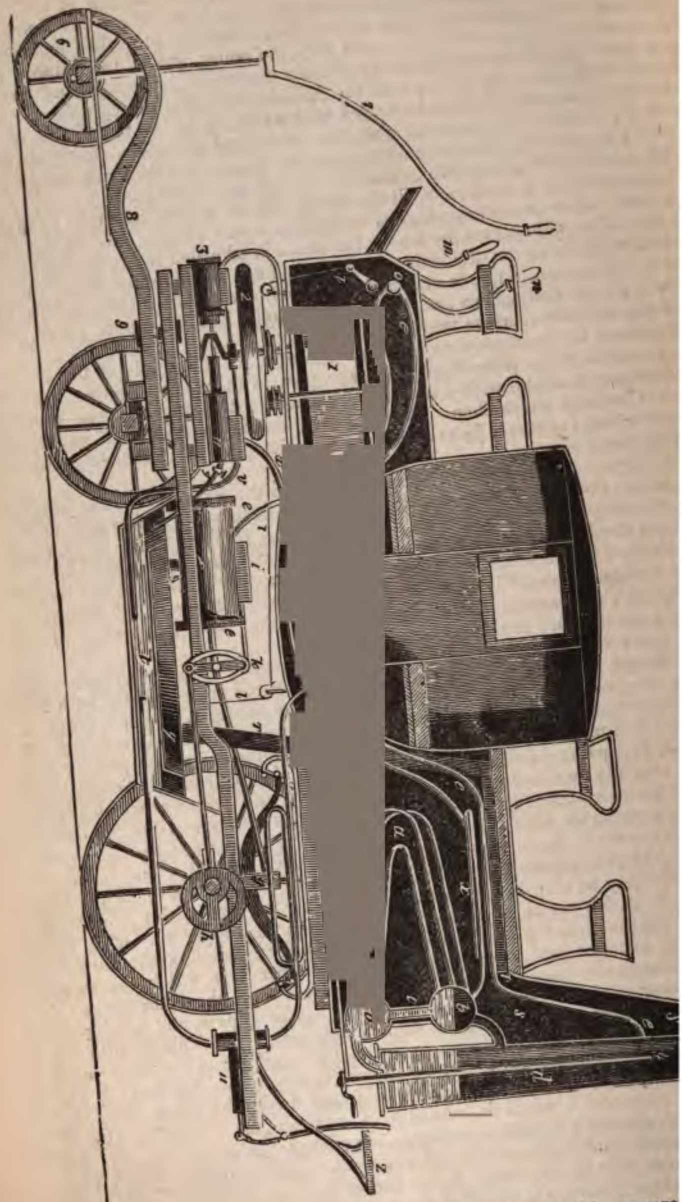
"I will now describe the general arrangement of my carriages.

"At the front sits the steersman, who governs the way and speed of the carriage; behind him is the body or open seats of the carriage, whichever may be its build; at the back of the body, and with a good screen or partition between it and the passengers, is the engine room, containing a pair of inverted engines, working direct upon the crank shaft, from which motion is communicated to the axle of the hind or working wheels, by endless chains and pulleys; adjoining the engine room, in the rear, is the boiler, with the fireplace under it. A lad stands behind to feed the fire as the carriage proceeds; and a man competent to judge of the working of the engines and machinery, and also to keep them oiled, is always in the engine room, whilst the carriage is working. The coke is contained in iron boxes at the back of the boiler, and the water for supplying the boiler is contained in tanks under the seats of the carriage. The fire is urged by a revolving blower under the flooring or body of the carriage.

"In conclusion, I will give a list of the carriages I have built, with the number of passengers they are each calculated to accommodate; not what they will and actually have carried, for this has sometimes, on particular occasions, been an increase of 50 per cent.; as an instance, the *Autopsy*, when first running to Islington, in 1833, carried, on two or three trips, 21 or 22 passengers, though its complement is but 12.



	Passengers. Inside.	Outside.	
1. Experimental Carriage .	—	—	Broken up.
2. Infant	—	14	
3. Era	16	4	
4. Enterprise	14	—	
5. Autopsy	10	2	
6. Erin	6	8	
7. German Drag	—	—	With Carriage attached.
8. Irish Drag	—	—	Ditto ditto
9. Gig	—	3	
10. Automaton	—	22 "	



The multifarious and unnecessary contrivances in this appara
reminds us of the man who employed a very common machine in
but who (being a "genius") took it into his head to disguise the

its working parts, by the addition of a great number of wheels and pinions, that he might, through their instrumentality, make a noise in the world. Although the preceding sectional drawing exhibits a faithful and clear outline of the "miraculous invention," there are of course many subordinate parts which are not introduced, to avoid a confusion of lines in the figure; enough are, however, left to surprise every mechanical reader, that such absurd additions should ever have entitled the author to the adulation of the press, and of some of our best parliamentary orators. It would be a waste of time to do more than just draw the reader's attention to a portion of the "happy series." First and foremost are the "pilot-wheels," already noticed in a previous page; next, under the fore boot, is exposed to the admiring gaze of the multitude a pretty little steam engine, with all appurtenances thereunto belonging, employed to raise the wind (in both senses of the term) and to cool the steam pipe; which pipe, it will be observed, after proceeding from the separators, makes a flourish over the boiler to get a little *warmed*, then descends in a graceful curve under the body of the carriage, and through the cold air-trunk, to get a little *cooled* in its complaisant journey to the coachman's feet: hence it makes a *détour* amongst the fanners, in order that the steam may be sufficiently condensed to run down into the engines, which are placed in the coolest possible situation, except when they happen to be covered with the non-conducting substances of quartz, silex, felspar, and mica, gathered from the road! It was for such patented contrivances as these, and those before described, that Mr. Gurney, or his friends in parliament, sought to obtain an extension of his patent rights, or a compensation in money for giving the public the entire benefit of his "sublime inventions!" On the latter proposition we have never made a single remark, nor is it our intention to do so; but of the former we cannot resist the expression of our rooted conviction, that an extension of Mr. Gurney's patents is unwished for, even by himself, because there is not a single contrivance of the whole "happy series" which any *mechanic* would be mad enough to use, or rather *try* to use, were they freely offered to him.

To render more useful the establishment of a railroad through a broken country, it has been a desideratum to construct a carriage which shall move with as much facility upon a serpentine, or curved, as on a straight road; and at the same time not to lose the peculiar advantages which the common method of fixing the wheels on the axis possesses. It is also desirable to lessen, if possible, the amount of friction, by means not too complex. These two ends, Mr. William Howard proposed to attain in the construction of carriages upon the following principles:—"First, the connexion of the two beds of the axles at a point equidistant from each; and in the same manner the connexion between the hind bed of one waggon and the fore bed of that following it; or the fore bed of the leading waggon with any system of guide-wheels, so that the wheels not only of one waggon, but of a train will follow one another in the same curve, without more lateral friction than when on a straight line. Second. The making of the axle revolve in its journals, and at the same time rendering either one or both wheels capable of revolving independent of the axles, as in a common carriage. Third, the application of a simple friction-wheel to diminish the friction of the axis upon its journal." Mr. Howard next proceeds to explain these principles in detail. First, "If there be a track of a railroad of a circular form and we wish a carriage to move on it without lateral friction, the planes of the wheels must be parallel to the tangents of the two circles at the points where they rest on them, and each axle, consequently, in the direction of the radius of the circle. To find the point at which the axle must be connected to produce this effect, draw a perpendicular from the middle of each, and the intersection of these two perpendicular lines will be the point of junction required. The advantage of this over the common construction is that there the pivot of the beam connecting the axles is on the foremost axle, and consequently in turning, the hind wheels do not follow the tracks of the foremost ones, but describe a curve of smaller radius, causing great lateral friction on the rails. Second, The principle of making the wheels revolve with or without the axles in the present case, is to secure the advantages of the

axle generally revolving with the wheels, and, at the same time, to permit one wheel to revolve faster than its fellow, when moving on a curved part of the road. The trifling relative improvement which this would produce between the axle and the wheel, would admit of these being adapted with considerable exactness. Third, In the application of the friction-wheels, instead of an axle resting on the summit of a wheel, as is the usual method of application, and the only one known to the inventor, the wheel with its load is here made to rest upon the axle. According to these principles, the combination of which into a railway carriage forms the ground of a patent granted to Mr. Howard, the construction is to be as follows:—

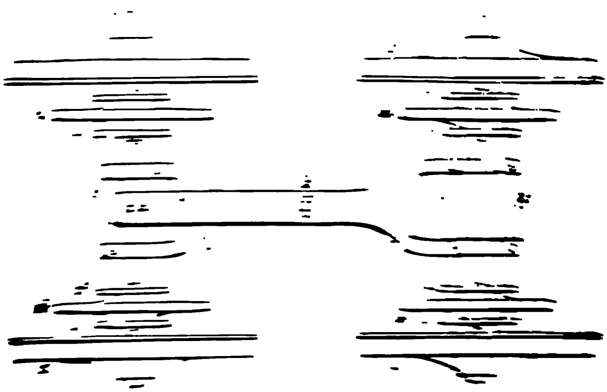
"The size of the wheels, their distance apart, and the distance between the axles, are in the common proportions used in railway carriages. The connecting beam between the fore and hind axles, is fastened firmly thereto by jaws or frames, to prevent lateral motion. This beam is divided in the centre, between the axles, one end having a tooth, and the other a socket, cut of the epicycloid form, to keep the point of action at an equal distance from the centres of each axle. The axles are kept together by fastening the body by bolts to the beds resting upon each. Another method of construction is, to extend the beam from the hind axle, until the end of it rests upon the bed of the fore axle, while the beam from the fore axle reaches to a short distance only behind the central point of action. A bolt then passed through the centre of the hind frame, and the end of the fore frame, and equi-distant from the axles, forms the pivot or point of action between them. In this case, the waggon is fastened firmly to the hind bed only, and to the extremity of the hind beam, which rests on the fore bed, which is made to traverse, laterally, more easily by a small roller upon a curved strip of iron. The friction-wheels are contained between upright stands or supports, of cast or wrought iron; each wheel having one on each side, connected at the top by a bolt and nuts, and having jaws at the bottom, wide enough to admit the axle in contact with the friction-wheel; each pair of friction-wheels is connected by iron bars passing through each arm of the jaws of the supports, and secured by nuts: between these bars the axle revolves, and the bars, rising above the axle, receive the beam, and form the fore and hind bends, to which the frames of the beam are securely nutted. To obviate the little friction which may arise from the centre of the friction-wheel being directly above the centre of the axle, it may be placed a little obliquely, and a small friction-roller used in one of the arms of the jaws, to destroy the additional friction there. The axles have two shoulders at each end, one of which supports the waggon wheel, and is either firmly fixed to it, or only secured by a linch-pin, and the other revolves upon the friction-wheel.

"These principles are not new, but the combination of them into a railway carriage is new, and entitles, the inventor believes, that his invention be secured by patent. The peculiar application of friction-wheels is also new, and claimed as original."

Fig. 1, (see opposite page,) represents a perspective view of the whole carriage, with its friction-wheels attached.

Fig. 2, represents the plan of the waggon, showing particularly the manner in which the beds of the two axles are connected. *a* is the iron waggon wheel, made as usual, except that it is arranged so as to turn on the axle, to which it is secured by the linch-pin *b*, or any other contrivance. *c* is a wheel fixed upon the axle, as in the common railroad carriage. *d d*, the friction wheels moving upon the axles *e e*, and supported by the supports *f f*. The whole of these parts are of wrought or cast iron, and the frames are secured together by screws and nuts, so as to keep them solid, and as shown in the figure *g*, one of the bars connecting the two frames together, and secured in like manner. *h* and *i* are the two frames by which the two beds are connected by a bolt, at the point *k*, equi-distant from the centre of each axletree; the ...me *i* of the hind bed is prolonged, and rests on part of the frame *h*, ...mediately over the fore axle, the motion of its end, laterally, being faci...ted by a small roller at *l*.

"If it be found objectionable to place the body of the waggon entirely



blow. The object of my invention is to accumulate and preserve the regular power which the wind produces, so that it may be applied to machinery to produce an uniform and regular motion whenever it is wanted." The ingenious inventor then proceeds to describe his condensing mechanism, and the construction of his vessels for containing the condensed air. But as no particular objects are specified for its application (except cursorily, the raising of water,) it would be out of place here to enlarge on the subject; and our only reason for noticing it now, is to show what degree of originality appertains to the next invention we have to introduce to the reader's attention.

This was the subject of a patent granted to Charles C. Bombas, Esq. It was especially designed for the propulsion of carriages or boats, and is dated the 29th of April, 1828. The patentee specifies it as consisting in the condensing of atmospheric air or gas in strong cylindrical reservoirs having spherical ends; whence it is to be discharged through proper valves and tubes into a cylinder, where it is to operate upon a piston in the same manner as in steam-engines, and communicate motion to the wheels of a carriage, or the paddles of a boat. The vessels to hold the condensed air or gas, are proposed to be from 12 to 18 inches in diameter, and of as great length as can be conveniently stowed, or removed into or out of the vehicle, from or to the stations which it is proposed to establish along the line of road whereon the traffic takes place, for the purpose of receiving the exhausted vessel, and supplying a charged one in its place; which it is proposed shall contain from 30 to 150 atmospheres. The particular construction of the engine and machinery of the carriage are not given; but it is directed on the plan of the high pressure steam engine, and to be worked expansively.

An efficient mode of working an engine with an uniformity of force, by means of a fluid that is constantly diminishing in its elasticity, is, we believe, a problem not yet solved. Another patent for precisely the same object as Mr. Bombas's, was granted on the 1st of June following, to Mr. W. Mann, of Effra-road, Brixton, Surrey, who was of course uninformed at the time of his having been anticipated. Nevertheless Mr. Mann pursued his undertaking, published a pamphlet descriptive of his plans, accompanied by drawings, and endeavoured to raise a company to carry his project into operation. Whether he actually carried it experimentally into practice we are uncertain, but a drawing of the carriage and reservoirs of compressed air are given in the 5th Vol. N. S. of the *Register of Arts*:—

"Mr. Mann proposes, like his predecessors, to employ a series of strong metallic recipients, similar to the cylindrical vessels used for portable gas, into which thirty or more atmospheres are to be condensed by the power of a steam-engine, water mill, or other adequate prime mover. A sufficient number of these vessels are stowed in a case adapted for the purpose, which is to be fixed underneath the carriage; a tube, communicating with all the recipients, is to convey the compressed air to two working cylinders, having the apparatus common to high pressure steam-engines, the piston rods of which will give motion to a crank on the axis of the hind running wheels. It is proposed to work expansively, and to vary the cutting off the stroke, according to the degree of elasticity of the air.

"The velocity Mr. Mann proposed to travel, was 14 miles in the hour, which he calculates will require 2000 cubic feet, of the natural density, to propel a carriage weighing, with its load, two tons. When the roads are in a bad state, it is intended to charge the vessels with a greater number of atmospheres, to overcome the increased resistance.

"The patentee states, that the carriage is *constructed* (?) to carry 75 cubic feet of compressed air, which, at a density of thirty-two atmospheres, is sufficient to propel it 14 miles; and if the air were compressed to be equal to 48 atmospheres, that quantity would propel the carriage 23 miles; and if to 64 atmospheres, 34 miles. The average cost of the power is calculated at one penny per mile; that is, if a steam-engine be employed to effect the compression of the air into the recipients, the cost in coals of such steam power, to condense a volume of air sufficient, by its subsequent expansion, to propel a carriage one

mile, is one penny. Mr. Mann, however, must know that this would only form one item in the expense of working a carriage. The proposition of propelling by a process of this kind, is certainly specious; but those who have given the subject their best attention, consider that no practical means have yet been devised to compensate for the constantly decreasing expansive force of the air in the recipients."

A suspension railway, combining the characteristic features of Mr. Palmer's and Mr. Fisher's, previously described, was patented by Mr. Maxwell Dick, of Irving, in Ayrshire, on the 21st of May, 1829; doubtless, in ignorance of those precedents, as we were personally assured by the latter patentee. The chief object of this gentleman was, as is stated in the title of his patent, "for the conveyance of passengers, letters, intelligence, packages, and other goods, with *great velocity*. The means which he adopts for this purpose, are designed to obviate the necessity and enormous expense of cutting and embanking resorted to on railways of the ordinary kind. The rail is supported, like Mr. Palmer's, upon vertical pillars, but carrying a double track for the carriages, like Mr. Fisher's. Mr. Dick has, however, added, what he denominates "safety rails," one on each side of the track, against which anti-friction wheels, attached to the carriages, are made to act, in case of the carriages receiving from any cause an impulse upwards. The patent likewise embraces a curious combination of wheel-work, for communicating a high velocity to the carriages. A large and well constructed working model of this invention was publicly exhibited for several weeks at Charing Cross, London, in 1830, and drew crowds of visitors, who were surprised and delighted at the velocity with which the carriages darted along the wire rails across the room, by the application of a small force. The notoriety of this invention, as well as the capability of its being usefully applied under many circumstances and situations, for light loads at high velocities, seems to require from us something more than this brief historical notice. Accordingly we proceed to give a few, out of the many details and modifications, which the prolific mind of the inventor has thrown together in his specification. From this document we learn that the patentee especially designed his invention for traversing undulating, rugged, and abrupt ground, the crossing of rivers, mosses, marshes, &c. Pillars are to be erected of brick or stone with lime, at given distances apart, suppose fifty yards; between each of these may be placed four or five cast metal pillars, according to circumstances, for bestowing the requisite stability and keeping the rail free from undulations. On the top of each of the pillars is to be fastened a frame, to which the rails are to be secured, and to the frames are connected grooved friction wheels or pulleys, between which the drag-line is conducted. The rails are to be made of the best wrought iron, such as is used for chain cables, and they are to be duly connected together in great lengths, and secured to the frames in such manner as to make the top surface smooth, and free from all obstruction to the motion of the carriages. Between each frame there are to be introduced three or four cast-iron braces, to prevent vibration and stiffen the structure. The method proposed for dragging the carriage along the railway, is by fixed or stationary engines acting with drag-lines or ropes attached to the carriage, which, if the railway be double, (as in the subjoined illustration) will act in an endless round; but if the line of railway be single, then the engine will be interchangeable and reciprocal.

Fig. 1.

Fig. 1 represents a side elevation of one span of a double suspension railway, supported at the *extremities* by a pier of masonry, *d d*, and at equal distances by

four cast-metal pillars *e e e e*. *a* is the upper or "bearing rail;" *b* the lower or "safety rail," which are bound together by intermediate stay braces, better shown on a larger scale at *f f* in figures 2, 3, and 4.

Fig. 2 shows a front elevation of a frame *e e e*, for a double line of rail, with a carriage on one of them at *g*. The letters of reference in this figure, as in all the others, designate similar parts; it therefore need only be said, that the stay braces *f f* are seen in section between the rails *a b*.

Fig. 2.

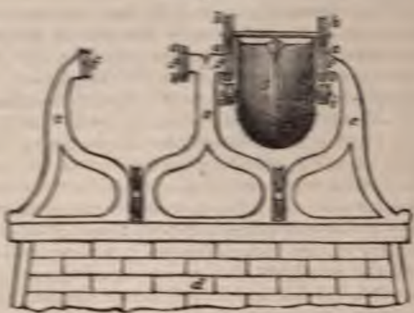


Fig. 3 gives a side elevation of a carriage on a portion of rail; *h h h* being the running wheels, and *i i i* the anti-friction rollers, which prevent the carriage from being thrown off the railway. An examination of *Fig.* 2, which exhibits the end view of this carriage, will fully explain its form and construction.

Fig. 4 is a perspective sketch of one of the stay braces on a larger scale. The expense of one mile of railway on this principle is calculated at 1395*l.* 10*s.* 6*d.* The advantages contemplated are stated by Mr. Dick as follows: "In the first place, as you save distance, so do you save time; which all must admit, that in a commercial as well as in a political point of view, is of the utmost importance.

Fig. 3.

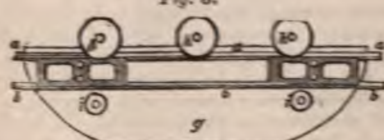
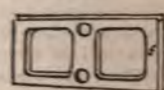


Fig. 4.



The suspension rail takes a straightforward point from one town to another, without regard to the surface of country over which it has to go, whether rising or falling, crossing of rivers, or otherwise. All are, by regulating the heights of the pillars, with the same ease gone over; and by that means saving of distance, saving of surface ground, saving bends in the formation of the rail; which bends, besides the extra expense of originally laying, are always liable to great derangement from the lateral friction of the waggons coming round them, compared to that of a straight line of rail. Secondly, the suspension railway, over that of the ground railway, has another immense advantage; that is, as far as expense is concerned, which is, in the saving of all embankments, excavations, building of bridges, cutting of tunnels, besides the great breadth of surface ground. Thirdly, and which I think the most important of all, is the great despatch to be gained by the suspension railway, without, in the least degree, endangering either persons or property, its height being sufficient at all places to allow every agricultural and commercial intercourse to go

on under it without interruption; and then the carriages being so completely locked within the rail, prevents any chance of their escape, whatever may be their velocity; so that I do not stretch a point when I say, with light carriages containing the mail, and all small packages, a velocity of sixty miles an hour is to be obtained, including all stoppages, and that with the greatest ease and safety."

Of all the railways hitherto constructed, that which now connects Manchester with Liverpool is, beyond all comparison, the most perfect and the most extensively useful. The peculiar commercial connexion between those towns renders a cheap and rapid communication not merely of local, but of national interest. Liverpool is the port whence Manchester receives all her raw materials, and to which she returns a large portion of manufactured goods for shipment to all parts of the world. By means of the railroad, the transit of goods is now effected in about two hours, which is about one-eighteenth part of the time previously occupied by the water carriage of fifty miles, besides a saving of fifty per cent. in the cost per ton of carriage; making an annual saving in carriage to the cotton manufacturers of 20,000*l.*; rendering it unnecessary for them to keep a stock on hand to meet sudden orders. Manchester, we may observe, has now all the advantages of a sea-port, since a cargo may be delivered into a warehouse at Manchester on the same day that it is received at Liverpool. These towns are, by thirty-two miles of railway, as much connected for the purposes of business or pleasure, as the eastern and western extremities of London; the facilities of communication between the latter are, in fact, not so great as the former. The immense public advantages attending this great mechanical work, have, however, been so often and so ably set forth, in poetry as well as prose, that it will be quite needless to make any further remark on this head.

The undertaking was commenced in June 1826, under the direction of Mr. Geo. Stevenson. It was proposed to lay the railway as nearly as possible in a straight line; but the nature rendered this work one of immense labour and difficulty. Upwards of 200,000*l.* were expended in excavations and embankments; in bridges alone, over and under the railway, upwards of 99,000*l.*; and out of a total expenditure, amounting to 820,000*l.*, only the sum of 67,932*l.* for the railway itself, the particulars of which, as furnished by Mr. Booth, we subjoin; namely,

	£	s.	d.
Rails for a double way from Liverpool to Manchester, with occasional lines of communication, and additional side lines at the different depôts, being about thirty-five miles of double way, weight 35 lbs. per lineal yard = 3847 tons, at prices averaging something less than 12*l.* 10*s.* per ton	48,000	0	0
Cast-iron chairs, 1428 tons, at an average of 10*l.* 10*s.*	15,000	0	0
Spikes and keys, to fasten the chairs to the blocks, and the rails to the chairs	3,830	0	0
Oak plugs, for the blocks	615	0	0
Sundry freights, cartages, &c.	487	0	0
Total	£67,932	0	0

The following summary view of the working of the concern, during the first fifteen months of its existence, obtained from an Annual Report from the directors to the proprietors, we insert, as furnishing some important data to all persons interested in similar undertakings:—

	£	s.	d.
The profits of the Company, from the opening of the railway on the 16th September, to 31st December, 1830, were	14,432	19	5
Ditto for the half year ending 30th June, 1831	30,314	9	10
Ditto for the half year ending 31st December, 1831	40,783	3	7
	85,530	12	10
Paid to the proprietors in dividends	80,165	12	6
Leaving a balance in the hands of the treasurer of	£5,365	0	4

to meet those contingencies to which the working of every extensive and new undertaking may be considered more or less liable.

The following general abstract of the expenditure of the railway, to the 31st of May, 1830, showing the cost of the different branches of the undertaking, may be of considerable use to those who shall hereinafter em ark in similar adventures :—

				£	s.	d.
Advertising account				332	1	4
Brick-making account				9,724	4	4
Bridge account				99,065	11	9
Charge for direction				1,911	0	0
Charge for fencing				10,202	16	5
Cart establishment				461	6	3
Chat Moss account *				27,719	11	10
Cuttings and embankments †				199,763	8	0
Carrying department, comprising account expended in land and buildings for stations and depôts, warehouses, offices, &c. at the Liverpool end	£35,538	0	0			
Expended at the Manchester station	6,159	0	0			
Side tunnel	2,485	0	0			
Gas-light account, including cost of pipes, gasometer, &c.	1,046	0	0			
Engines, coaches, machines, &c.	10,991	11	4			
				56,219	11	4
Formation of the road ‡				20,568	15	5
Rail account				67,912	0	0
Carried forward				£479,880	16	8

* The embankments included under this head consist of about 277,000 cubic yards of raw moss earth, in the formation of which, about 677,000 cubic yards of raw moss have been used; the difference in measurement being occasioned by the squeezing out of the superabundant water, and consequent consolidation of the moss. The expenditure on this part of the line has been less than the average expenditure.

† Under this head is comprised the earth work on the whole line, exclusive of the Chat Moss district. The cuttings somewhat exceed the embankings; the surplus is principally deposited along the border of the Great Kenyon Cutting. The excavations consist of about 722,000 cubic yards of rock and shole, and about 2,006,000 cubic yards of marl, earth, and sand. This aggregate mass has been removed to various distances, from a few furlongs to between three and four miles; and no inconsiderable portion of it has been hoisted up by machinery, from a depth of thirty to sixty feet, to be deposited on the surface above, either to remain in permanent spoil banks, or to be afterwards carried to the next embankment.

‡ By this is understood what is termed ballasting the road,—that is, depositing a layer of broken rock and sand, about two feet thick; viz. one foot below the blocks, and one foot distributed between them, serving to keep them firm in their places. Spiking down the iron chains to the blocks or sleepers, fastening the rails to the chains with iron keys, and adjusting the railway to the exact width, and curve, and level, come under this head of expenditure.

Brought forward				£479.880	16	8
This expenditure comprises the following items:—						
Rails for a double way from Liverpool to Manchester, with occasional lines of communication, and additional side-lines at the different depôts, being about 35 miles of double way = 3,847 tons, at prices averaging something less than 12*l.* 10*s.* per ton	£48,000	0	0			
Cast-iron chains, 1,428 tons, at an average of 10*l.* 10*s.*	15,000	0	0			
Spikes and keys to fasten the chains to the blocks, and the rails to the chains	3,830	0	0			
Oak plugs for the blocks	615	0	0			
Sundry freights, cartages, &c. . .	467	0	0			
Interest account (balance)				3,629	16	7
Land account				95,305	8	8
Office establishment				4,929	8	7
Parliamentary and law expenditure				28,465	6	11
Stone blocks and sleepers *				20,520	14	5
Surveying account				19,829	8	7
Travelling account				1,423	1	5
Tunnel account				34,791	4	9
Tunnel compensation account				9,997	5	7
Waggons used in the progress of the work . . .				24,185	5	7
Sundry payments for timber, iron, petty disbursements, &c.				2,227	17	3
Total . . .				£739,185	5	0

About 100,000*l.* more were required to complete the work.

Since the period mentioned, we understand that the traffic on the railway has been constantly increasing. We have already described the nature and construction of the rail employed in this road, but it becomes necessary to a comprehension of the great effects produced upon it, to add some account of the levels and inclined planes of which it is formed; and this information is afforded in the annexed table.

	Miles.	Yds.	Planes.
Tunnell under the Town of Liverpool, from Wapping to Edge-hill	1	240	Rise, 1 in 48.
Level	0	1000	Level.
To the Foot of Whiston, or Rainhill Plane . .	5	220	Fall, 1 in 1092.
Rainhill inclination	1	880	Rise, 1 in 96.
Rainhill level	1	1540	Level.
Sutton plane	1	880	Fall, 1 in 96.
Parr Moss	2	880	Fall, 1 in 2640.
Ditto	6	880	Fall, 1 in 880.
Chat Moss	5	880	Rise, 1 in 1200.
To Manchester	4	880	Level.
Total	30	1240	

* Out of thirty-one miles, eighteen are laid with stone blocks, and thirteen with wooden sleepers or larch; the latter being laid principally across the embankment and across the two districts of moss.

The tunnel under Liverpool, which commences in Wapping, near the Queen's Dock, and ends at Edge Hill, outside the town, was constructed in seven or eight separate lengths, each communicating with the surface by means of perpendicular shafts. This tunnel is whitewashed throughout, and lighted with gas, and the effect produced is very singular and picturesque. The whitened roof and sides contiguous to each light are so strongly illumined, that the whole vista (observes Mr. Walker, in his "Description of the Railway,") appears like a succession of superb arches formed through massive parallel walls, the intervening spaces being left in comparative darkness. About half a mile from the tunnel the railroad crosses Wavertree-lane. Half a mile to the north of Wavertree, at Olive Mount, there is an excavation through the solid rock, 70 feet below the surface, and two miles in length. The road is then carried by means of a great embankment, varying from 15 to 45 feet in height, and from 60 to 135 feet in breadth at the base, across a valley at Roby, or Broadgreen, two miles in length. It then crosses the Hayton turnpike road, a little past Roby; six miles and three quarters from Liverpool there is a junction railway for the conveyance of coals from the neighbouring mines; on the right, and at a distance of seven or eight miles from the Liverpool station, it comes to the Whiston inclined plane, which is one mile and a half long, and rises about 1 in 96. There is here a stationary engine to assist the carriages in their ascent. For nearly two miles the road is then on an exact level. It was on this part of the road that the contest of locomotive carriages, for the premium of 500*l.*, took place in October, 1830, the result of which determined the directors to make use of locomotive engines instead of stationary ones. About half a mile from the Whiston plane, at Rainhill, the Liverpool and Manchester turnpike-road crosses the railway, at an angle of thirty-four degrees. On leaving the level at Rainhill, the railway crosses the Sutton inclined plane, which is of the same extent as that at Whiston, and descends in the same proportion that the other rises. There is here another stationary engine. A little beyond Rainhill several collieries communicate with the road by means of railways, and the Runcorn Gap railway will here cross the line to St. Helen's.

The next object of interest is Parr Moss, the road over which is formed principally of the clay and stone dug out of the Sutton inclined plane, and extends about three quarters of a mile. The moss was originally about twenty feet deep, and the embankment across it is nearly twenty-five feet high, though only four or five feet now appear above the surface, the rest having sunk below it. The road is then carried over the valley of Sanky, by means of a massive and handsome viaduct, consisting of nine arches, of fifty feet span each; the height of the parapet being seventy feet above the Sankey canal in the valley beneath. The viaduct is built principally of brick, with stone facings, and the foundations rest on piles of from twenty to thirty feet in length, driven into the ground. The breadth of the railway between the parapets is twenty-five feet. The viaduct is approached by a stupendous embankment, formed principally of the clay dug from the high lands surrounding the valley. A little to the south of the town of Newton the railway crosses a narrow valley, by the short but lofty embankment of Sandy Mains, and a handsome bridge of four arches, each forty feet span, under one of which passes the Newton and Warrington turnpike road. The Wigan and Newton branch here enters the railway.

A few miles beyond Newton is the great Kenyon excavation, from which above eight thousand cubic yards of clay and sand were dug out. The Kenyon and Leigh Junction railway here joins the Liverpool and Manchester line, and, as it also joins the Bolton and Leigh line, brings into a direct communication Liverpool and Bolton. The Liverpool and Manchester railway then passes successively under three handsome bridges; and a little beyond Culcheth, over the Brosely embankment, which is about a mile and a half in length, and from eighteen to twenty feet in height. It then passes over Bury-lane, and the small river Gless, or Glazebrook, and a river at Chat Moss. This is a huge bog, comprising an area of about twelve square miles, so soft, that cattle cannot walk over it, and in many parts so fluid, that an iron rod laid upon the surface ·uld sink to the bottom, by the effect of its own gravity. It is from ten to

thirty-five feet deep, and the bottom is composed of clay and sand. It was accounted by some an impossibility to carry the road across this huge bog; but by ingenuity and perseverance the work has been effected, and a firm road is now carried across the moss. Hurdles of brushwood and heath are placed under the wooden sleepers, supporting the rails over the greatest part of the moss, and the road may be said to float on the surface. The most difficult part was on the eastern border, extending about half a mile, where an embankment of twenty feet in height was made, and many thousand cubic feet of earth sank into the moss, and disappeared, before the line of road approached the proposed level. At length, however, it became consolidated; in 1829, one railway was laid over the whole moss, and on the 1st of January, 1830, the *Rocket* steam engine, with a carriage and passengers passed over it. The line extends across the moss, a distance of about four miles and three quarters, and the road is not inferior to any other part of the railway. The work was completed at an expense of 27,719*l.* 11*s.* 10*d.*

On leaving Chat Moss, the road passes over the lowlands at Barton, extending about a mile between the Moss and Worsley canal, by means of an embankment; it is carried over the canal by a neat stone viaduct of two arches; it then proceeds through Eccles, and a portion of Salford, under six bridges; it is carried over the Irwell by a handsome stone bridge of sixty-three feet span, thirty feet from the water, and then over twenty-two brick arches, and a bridge over Water-street, to the Company's station in Water-street, Manchester, a distance of thirty-one miles from the Liverpool station. The railway is there on a level with the second story of the Company's warehouses. On the line between Liverpool and Manchester, there are, besides culverts and foot bridges, sixty-three bridges, of which thirty pass under the turnpike-road, twenty-eight over it, four over brooks, &c., and one over the river Irwell. There are twenty-two of brick, seventeen of wood and brick, eleven of brick and stone, eleven of wood, and two of stone and wood, at a total expense of 99,065*l.* 11*s.* 9*d.*

From the top of the Liverpool tunnel to Manchester, with the exception of two inclined planes at Parnhill, (one ascending and the other descending at an inclination of one in ninety-six, and where some assistant power must be used,) there is no greater inclination than in the ratio of about one in eight hundred and thirty; and since the advantage on the descending side will nearly counterbalance the disadvantage in ascending so gradual a slope, the railway may be regarded, for practical purposes, as nearly horizontal. The rails at the mouth of the tunnel, at Edge Hill, are forty-six feet above the rails at the Manchester end of the line.

In the formation of the railway, there have been dug out of the different excavations, upwards of three millions of cubic yards of stone, clay, and soil; which is equal to, at least, four millions of tons!

After mature consideration of the reports and calculations of various engineers, appointed to consider the most eligible description of power for the Manchester and Liverpool railroad, they determined upon preferring locomotive to fixed engines, provided the former could be made sufficiently powerful, and at the same time not of so great a weight as to injure the stability of the rails, and that would not emit smoke, which is one of the provisions of the Railway Act. With the view also to obtain, if possible, an engine of improved construction, a public reward was offered by the directors in April 1829, for the best locomotive engine, subject to certain stipulations and conditions, which may be thus briefly stated: viz. to consume its own smoke: to be capable of drawing after three times its own weight, at ten miles an hour, and have not exceeding 50lbs pressure upon the square inch on the boiler: two safety valves, one locked up: engine and boiler to be supported on springs, and rest on six wheels if it should exceed 4½ tons: height to top of chimney not more than 15 feet: weight, including water in boiler, not to exceed 6 tons; but preferred if of less weight: boiler, &c., proved to bear three times its working pressure: pressure gauge provided: cost of machine to be not more than 550*l.*

On the day appointed, the following engines were entered for trial for the prize; and the judges appointed to decide were, Mr. Nicholas Wood, of Killing-

worth, (the eminent writer upon railways, to whose labours we stand much indebted in this article); Mr. Rastrick, of Stourbridge, and Mr. Kennedy, of Manchester, who made judicious arrangements.

The *Rocket*	Steam locomotive,	by Mr. Robert Stevenson.
The *Novelty*	ditto	by Messrs. Braithwaite & Erricson.
The *Sans Pareil*	ditto	by Mr. Timothy Hackworth.
The *Perseverance*	ditto	by Mr. Burstall of Edinburgh.
The *Cyclopęde*	Horse locomotive,	by Mr. Brandreth, of Liverpool.

The trial, as before mentioned, took place on the level at Rainhill. Several days were employed in getting them into the best working condition for the contest.

	Ton.	cwt.	qr.	lb.
The *Rocket* weighed	4	5	0	0
Tender, with water and coke . .	3	4	0	2
Two loaded carriages attached .	9	10	3	26
Total weight in motion . . .	17	0	0	0

The rate of performance of this engine was found by the judges to be 70 miles in about five hours, or 14 miles per hour; with an evaporation of 114 gallons per hour, and a consumption of coke of 217lbs. per hour. The greatest velocity attained was on the last eastward trip, the 1½ mile being accomplished in 3′ 44, which is at the rate of 24⅛ miles per hour.

On the following day the next engine brought up to the starting post was the *Sans Pareil*, but on weighing, it was found to exceed the condition of 4½ tons upon four wheels, therefore could not strictly compete for the prize. Nevertheless, it underwent a trial of its powers, in order that the Directors might be acquainted with its merits.

	Ton.	cwt.	qr.	lb.
The weight of the *Sans Pareil* . . .	4	15	2	0
Tender with water and fuel	3	6	3	0
Three loaded carriages attached . . .	10	19	3	0
Total weight in motion	19	2	0	0

In making the eighth trip on the running ground, the pump that supplied the water to the boiler became disordered in its action, by which the level of the water in the boiler became reduced below the fire tube, and the leader plug, employed as a safety valve, was melted, and put an end to the experiment. But as far as the experiment was conducted, which extended to 27½ miles, the performance was creditable, being 19¼ tons conveyed at the rate of 15 miles per hour. The greatest velocity attained was in the fifth trip; the 1½ mile being traversed in 3′ 59″, which is at the rate 22¾ miles per hour. The consumption of the coke in this engine was enormous, being at the rate of 692lbs per hour, which was found to be owing to the draft through the fire-place being so powerful, as to blow red hot cinders out of the chimney shaft.

The *Novelty*, which was not tried until the 10th, owing to unavoidable circumstances, carried its own water and fuel; and, therefore, to place it on the same footing as the other engines, the same proportion of useful load was assigned to it when compared to the engine, as the useful loads taken by the other engines have to their weight. The power and its load were accordingly as follow:—

	Tons.	cwt.	qrs.	lbs.
Weight of the *Novelty*, with water in the boiler .	3	1	0	0
Tank, water, and fuel	0	16	0	14
Two loaded carriages attached	6	17	0	0
Total weight in motion . . .	10	14	0	14

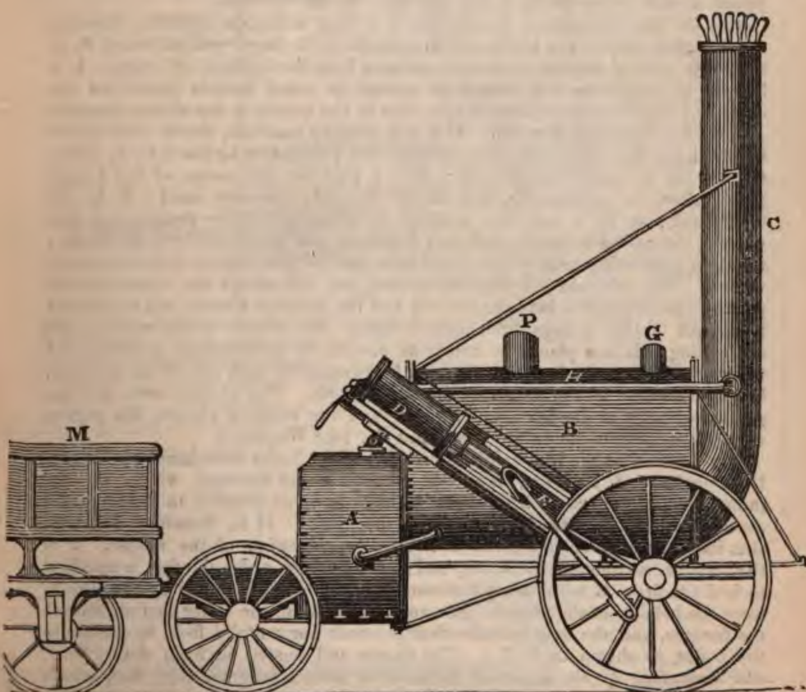
In the early part of the trial with this engine, the water supply-pipe burst, and put an end to the experiment for that day. Two or three days afterwards the trial was renewed, but another unfortunate accident (that of one of the joints of the boiler giving way) terminated the proceedings, at the desire of Mr. Erricson, who voluntarily withdrew his carriage from the contest. The performance of the engine, while it lasted, indicated very excellent results; the design, arrangement, and execution of the work, were likewise highly creditable to the genius and talent of the proprietors.

The *Perseverance*, after a short trial, was proved unsuited to the railway, and was immediately withdrawn by the proprietor. The course was thus left clear for Mr. Stevenson to receive the fairly won prize of 500*l.*, which was awarded to him by the judges.

The *Cyclopede*, though included in the foregoing list of rival machines, not being propelled by the power mentioned in the "stipulations and conditions," it could not properly be considered as entering the lists for the *prize* therein proposed; it was, however, an inquiry well worth the investigation, what degree of power horses could exert in a locomotive machine of the kind, and thereby determine its comparative economy with that of steam. For these reasons a trial of the *Cyclopede* took place; but it only attained a speed of five or six miles an hour, owing, as we believe, to the horses not having sufficient power to exert themselves in their stalls, as well as to an injudicious construction of some parts.

Having now stated the results of this memorable contest, it becomes necessary to give some account of the machines engaged therein.

The *Rocket*, constructed by Mr. Stevenson, of which an external side elevation is given in the following figure, possesses many of the characteristics of those



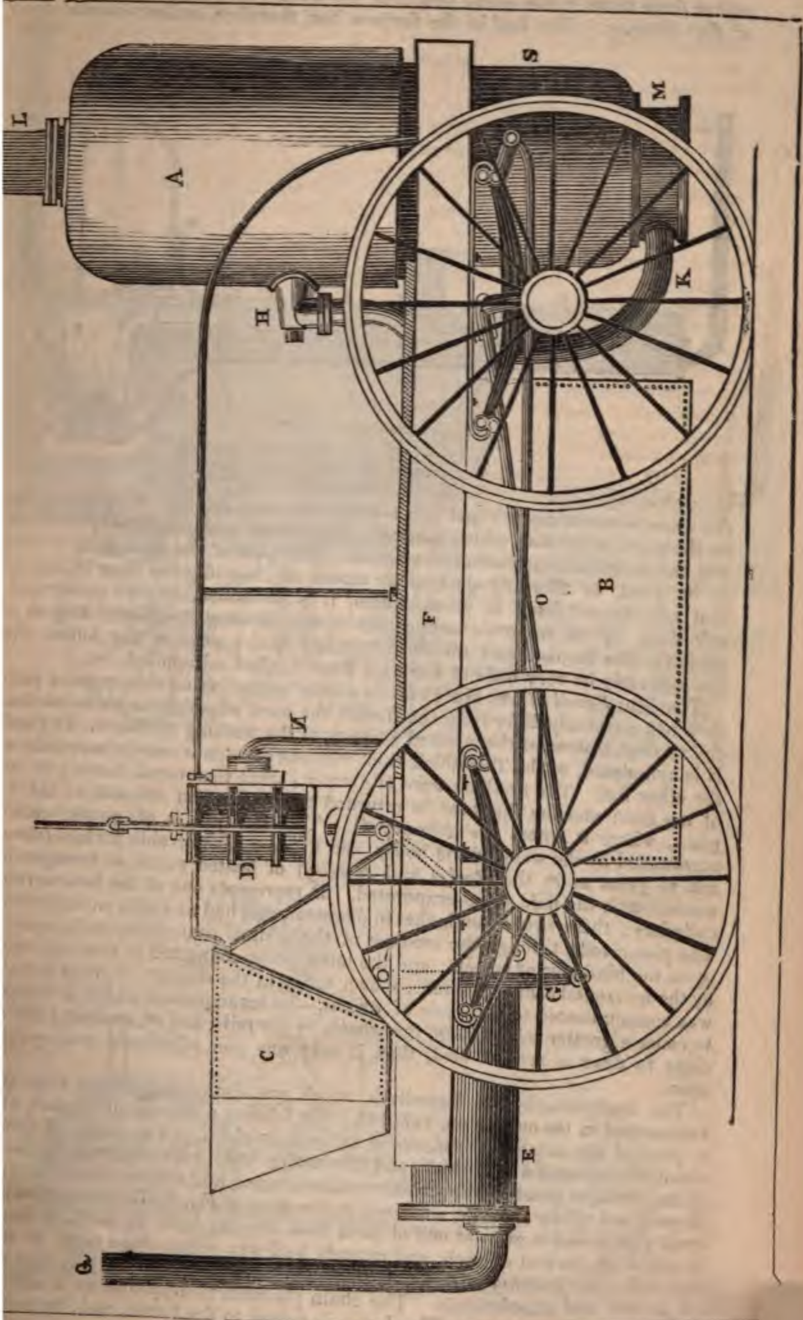
which were worked upon other railways, as already described. The furnace at A is a square box, about 3 feet wide, and 2 feet deep. This furnace has an external casing, between which and the fireplace there is a space of 3 inches filled with water, and communicating by a lateral pipe with the boiler. The heated air, &c. from the furnace passes through twenty-five copper tubes, 3 inches in diameter, arranged longitudinally on the lower half of the boiler, and then enters the chimney C. D represents one of the two steam cylinders, which are placed in an inclined position on each side of the boiler, and then enters the chimney C. D represents one of the two steam cylinders, which are placed in an inclined position on each side of the boiler, and communicating by their piston rods, through the media of connecting rods E, motion to the running wheels. P G are safety valves; E is one of two pipes on each side of the boiler, by which the eduction steam from the cylinders is thrown into the chimney, and, by the exhaustion thus caused in the latter, producing a rapid draft of air through the furnace. At M is exhibited part of the tender, which carries the fuel and water for the supply of the engine.

A little reflection upon the construction of this boiler will evidently show the great advantages it possesses of generating steam with rapidity, and hence the superior effects in propelling the carriage and its load. There are twenty square feet of heated metallic surface surrounding the furnace, the flames and heated matter from which infringe afterwards upon the twenty-five copper tubes lying immersed in the lower part of the boiler. These tubes contain 117 square feet of surface, making altogether 137 superficial feet of heated metal in contact with the water. We understand that Mr. Booth suggested the arrangement of the flue tubes leading from the furnace to the chimney; and we make no doubt that it was mainly owing to this contrivance that the prize was won by Mr. Stevenson's engine.

The *Novelty*, by Messrs. Braithwaite and Erricson, is exhibited in the subjoined sketch, representing a side elevation of the machine.

F is the carriage-frame; E, one end of a long horizontal cylinder, forming the principal part of the boiler, which extends to the large vertical vessel A, at the other end of the carriage, and contains forty-five gallons of water; L, a hopper to supply the fuel, (which is carried in small baskets placed on the carriage,) whence it is conducted by a tube in the centre of the steam-chamber A, into the furnace S, beneath. At C is a blowing machine, the air from which is conducted by a pipe under the carriage, and proceeding by the tube K enters the ash-pit M, under the furnace; Q is a pipe for the escape of the heated gases after the combustion, and forms the only chimney used; B is the water-tank; at D N are two working cylinders with their steam-pipes and valves; the cylinders are six inches in diameter, and have a twelve-inch stroke; O G are connecting-rods, which impart the force of the engines to the running-wheels. The axletrees are fixed to an iron rod, and slings are introduced to prevent the side action between the rod and the carriage frame; and to prevent the effect of the springs from counteracting the action of the engine, the connecting-rods are placed as nearly as possible in a horizontal position, and the motion is communicated to them by bell-cranks on each side of the carriage, being connected by the slings to the piston rods. The pistons used are the patent metallic of Barton (see PISTON); and the running wheels, the patent suspension kind, of Theodore Jones and Co. (see WHEELS.)

The figure, on page 146, exhibits a section of the boiler introduced by Messrs. Braithwaite and Erricson, into the *Novelty* steam-carriage, which we are induced to insert here, as it has been deemed, by some persons, to be the grand *desideratum* in this branch of practical mechanics. It is, therefore, desirable that its real merits should come under the consideration of the reader. S is the furnace, surrounded by water; and L the tube by which the fuel is supplied to feed the fire; M is the ash-pit, through which the air is forced by the pipe K from the bellows of the engine. The vessel containing the water that surrounds the furnace, and the long cylinder that proceeds horizontally from it, constitute *the boiler*, as shown at E E *e*. The flames and heated air from the furnace, *after ascending* by the action of the bellows, enter a long tortuous flue, which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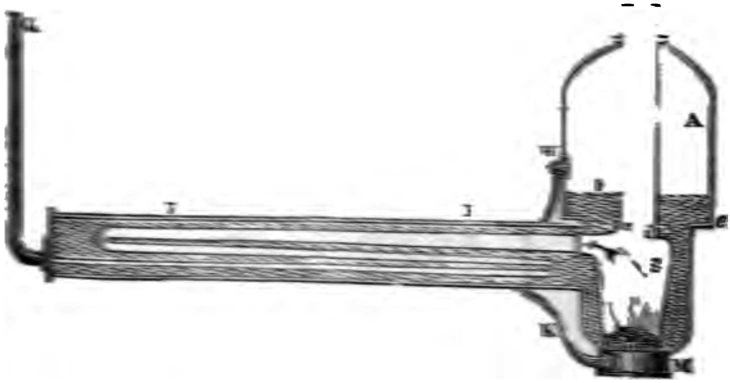
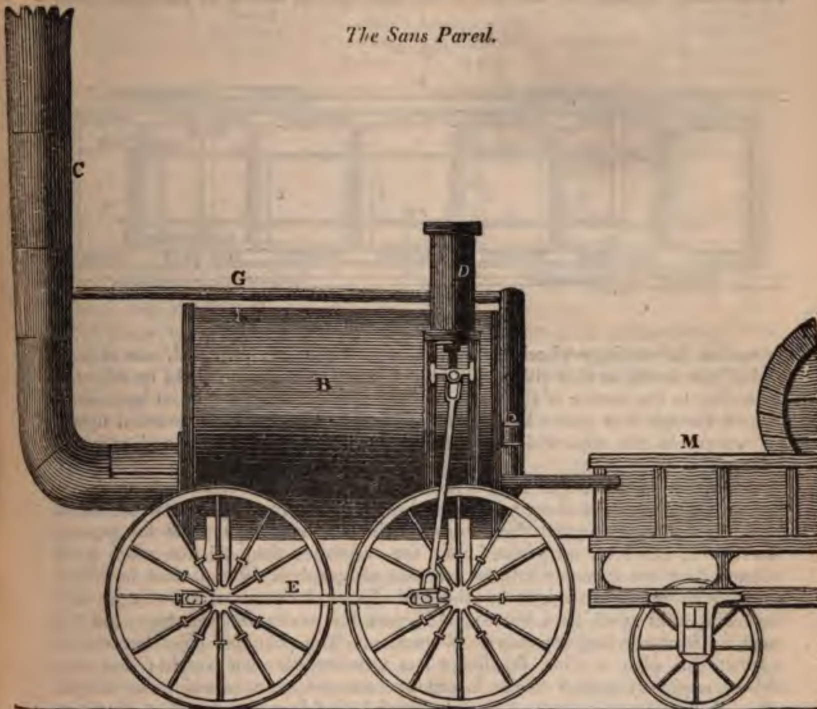


the water surrounding it; and the water in the long cylinder is operated upon by the gases in the tube, which gradually ascend from the furnace to the chimney, [illegible]. This part of the arrangement seems to be good, as affording convenient means of cleansing the tubes of any soot that may deposit itself in them, which, it is presumed, may be performed at any time [illegible] the moving machine; and as the whole of the furnace and flue is surrounded by the water of the boiler, there can [illegible] be very little of the heat from the fire dissipated.

The *Sans Pareil* of Mr. Hackworth (see the engraving on the opposite page), does not materially differ from the *R*[illegible], the most conspicuous variation being the vertical, instead of the inclined position, of the working cylinders. The boiler B is cylindrical, [illegible] with one of its ends convex outwards, and the other flat. The fire-bars were of greater extent than usual, having an area of ten feet; and the flue-tube is returned to the front on one side of the fire-place, where it enters the chimney C. This fire-tube is of course entirely surrounded by the water in the boiler, and hence a considerable surface, though not so great as in the *Rocket* and *Novelty*, of heated metal is brought into contact with the fluid to be evaporated. D represents one of the two working-cylinders; these were seven inches in diameter, and had an eighteen-inch stroke. The piston rods, through the medium of the vertical connecting rods, operated upon the hind pair of wheels; and the latter being connected to the fore wheels by the horizontal connecting rods, shown acting in the manner of cranks, motion was communicated to both pair of wheels—an arrangement which is designed to cause a greater adhesion of the wheels to the rails, and of enabling the carriage to draw a greater load than if only one pair of wheels was operated upon.

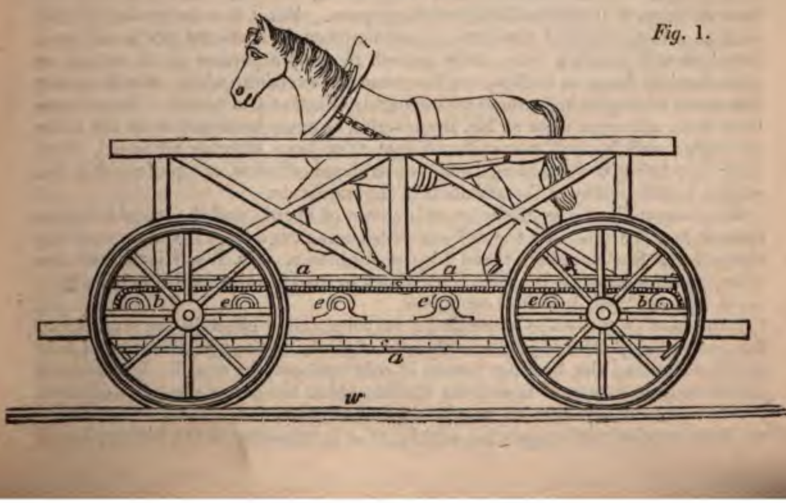
The *Cycloped*[illegible], by Mr. Brandreth, which was also tried upon the railway, is represented in the cuts on pp. 147, 148; *Fig.* 1 being a side elevation, and *Fig.* 2 a plan of the same. It consists in an endless chain, *a a a*, made of planks, about an inch and a half thick, and four inches wide, extending across the bed of the carriage, attached at their extremities to ropes, and carried over a drum *b b*, at each end of the carriage, as shown in the plan at *Fig.* 2. To strengthen these cross pieces, and to prevent one of them from slipping down by itself, a cleat *c c* is nailed on the end of each, and extends half-way across those next to it, on [illegible]h side: the position of these, as they pass over the drums *b b*, will best show [illegible] extent and attachments. The chain platform is supported on a series of [illegible]iction rollers *e e e e*. The horse is yoked to the frame, and, by treading

The Sans Pareil.



The Cyclopede.

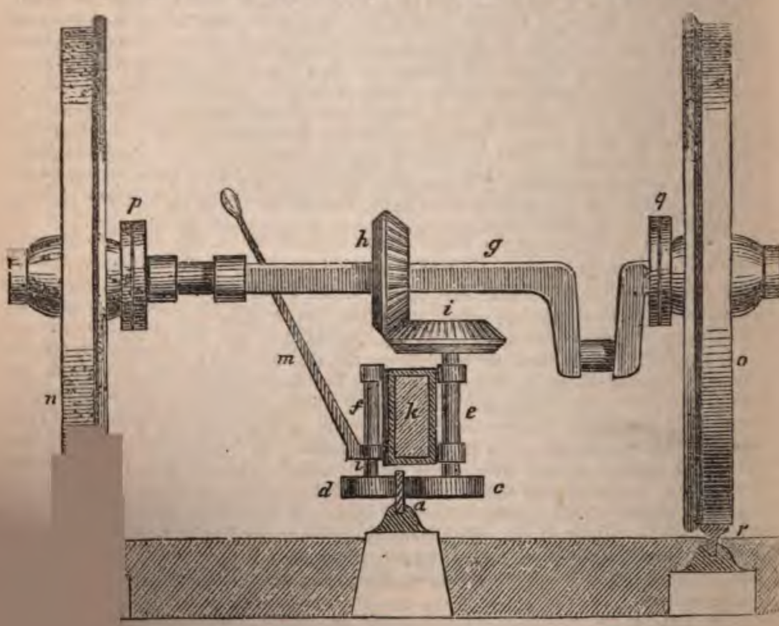
Fig. 1.



succession within each other. The difference between the diameters of the tubes is such as to leave annular spaces between them. The tubes are made somewhat conical, and they are placed alternately with their wide and narrow ends upwards, so that the spaces between them alternately taper towards the top and bottom. Those spaces which taper towards the top are open at both ends, and used as flues for the passage of flame, smoke, &c., from a furnace at the bottom of the apparatus; and the spaces which widen towards the top, are closed at both ends, and used to contain water and steam. A communication is introduced, for the passage of steam from one space to another. There are a series of openings for the escape of smoke, and to produce a draft through the flues. We have only described one of a series of boilers which the patentee proposed to employ when much power is required; and these he arranges in a circular position, or any other which may be found most suitable to the space to be appropriated to the boilers of steam carriages, the propelling of which seems to be his principal aim. The advantages contemplated by this arrangement are the great extent of surface exposed to the heat; but it will be readily perceived that this does not possess the strength of a tubular boiler, as all parts will necessarily be subjected to the same degree of pressure, and the exterior vessel must, from its size, be regarded rather as a cylindrical than a tubular boiler.

The foregoing is what the Colonel (now General) Viney describes as his invention; but he claims, in addition, the doing away with the use of separators and blowing-machines in steam carriages. With respect to the first of these extraordinary prohibitions, we must leave Mr. Gurney to contest the point with the gallant General.

One of the chief difficulties in the application of locomotive carriages to railways has been to obtain sufficient friction or adhesion between the driving wheels and the rails to cause them to ascend planes of considerable inclination



els are in such cases apt to be turned round without advancing the To prevent this, Messrs. Vignoles and Erricson propose to introduce

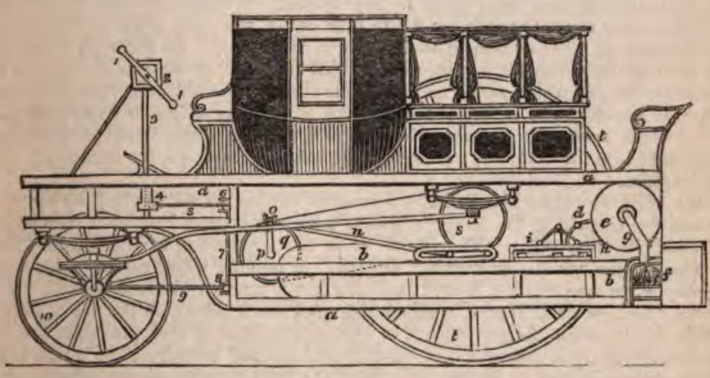
135 bags and bales of American cotton, 200 barrels of flour, 63 sacks of oatmeal, and 34 sacks of malt, weighing altogether 51 tons, 11 cwt. 1 quarter. To this must be added the weight of the waggons and oil-cloths, 23 tons, 8 cwt. 3 quarters. Tender, water and fuel, 4 tons, and 15 persons on the team, 1 ton, making a total weight of 80 tons, exclusive of the engine, about 6 tons. The journey was performed in 2 hours and 54 minutes, including three stoppages of 5 minutes each (one only being necessary under ordinary circumstances), for oiling, watering, and taking in fuel; under the disadvantages, also, of an adverse wind, and of a great additional friction in the wheels and axles, owing to their being entirely new. The team was assisted up the Rainhill inclined plane by other engines, at the rate of 9 miles an hour, and descended the Sutton incline at the rate of 16½ miles an hour. The average rate on the other parts of the road was 12½ miles an hour, the greatest speed on the level being 15½ miles an hour, which was maintained for a mile or two at different periods of the journey."—*Liverpool Paper*.

The annexed experiment shows the velocity of motion that had been attained on the railway at the period mentioned.

"The journey between the two places was on the 23d of November (1830) performed by the *Planet* engine in 60 minutes, including 2 minutes, the time employed in taking in water on the road, as usual.

"The motive for performing the journey was that the engine had been engaged to bring up from Manchester to Liverpool some voters for the election, and by some cause or other, the time of setting out was delayed, rendering it necessary to use *extraordinary* dispatch in order to convey the voters to Liverpool in time."—*Liverpool Paper*.

The application of compressed air to the propulsion of carriages, was also attempted by the ingenious Mr. Samuel W. Wright, who had a patent for the same in April, 1828. As the mechanical combinations of this gentleman usually possess great interest, from their originality and a skilful mode of applying them, we shall here introduce a description of his locomotive machine, with reference to the following cut.



The above figure represents a side view of the machine, partly in section. *a a a* is the frame work upon which the engines, machinery, and body of the carriage are mounted: at *b* there are two long metal cylinders (one being behind the other), having semispherical ends for containing the compressed atmospheric air; these vessels are filled by means of pipes and cocks, either from a stationary reservoir under the required pressure, or by means of air-pumps. For the purpose of increasing the elastic force of the compressed air, it is allowed to enter through pipes and cocks at *d* into a third cylinder *e*, *placed above the two,* and extending over one of their extremities; under the

middle of this third cylinder there is a small furnace, whereby the air is heated, and its expansive force increased before entering the working cylinders of the engines, which are situated at *l*. This heating is chiefly effected by a pipe *g*, proceeding from the furnace, and entering a series of tubes contained in the cylinder *e*. When the air has acquired sufficient elasticity, it is admitted through a pipe *h* into the slide valves *i*, and thence into the cylinders; the valves being worked by eccentrics and rods in the usual manner, as partly shown. The force is communicated by the piston rods to connecting rods at *n n*, which give rotation to the cranks at *o*, the shaft *p*, and the drums *q*, which are connected by bands or straps to the drums at *s*; these being fixed upon the naves of the running wheels *t t*, communicate motion thereto, and propel the carriage.

Steam may be generated by the furnace *f* in a small boiler or pipes, and be then conducted to the cylinder *e*, where giving out a portion of its heat to, and combining with, the compressed air, the air is thereby rendered more elastic. The heat or steam from the furnace *f* may be conducted to the engines (without using the third cylinder *e e*), and there unite with the compressed air from the cylinders.

Mr. Wright does not describe, but merely mentions that the man having charge of the machinery may, by "any proper connecting gear, control the working of the engines, valves, cocks, and force pump, and stop or abate the speed of, or set the carriage going, as may be requisite;" and he proposes that an eccentric motion be added to the shaft *p*, which, by a connecting rod, shall "work a pump, to compress and force air into either of the cylinders, when the carriage is going down hill, and which will serve also as a brake to check the speed in descending." When the carriage is to be guided out of the straight line, the winch-handles 1 1 are to be turned round, and a bevel wheel on their shaft 2, acting on another bevel wheel on the end of the upright rod 3, communicates motion to the pulley 4; upon this pulley are attached the ends of two chains, 5, their other ends being connected to the pulley 6, upon the shaft 7; on this shaft is another pulley 8, with the ends of two chains 9 9 fastened to it, their other end being connected to the opposite sides of the axle of the fore-wheels; upon motion being given to these drums, the chains are wound on and off them, and cause the axletree 9 9 to turn out of the right angle to the track of the carriage, thus causing it to travel in a curved line. At different stations on the road on which the carriage is intended to travel, strong metal reservoirs are to be placed, which are to be filled with atmospheric air, compressed to the required density by a common force pump, worked by steam or water power. From these reservoirs the air is to be passed through proper connecting pipes and cocks into the cylinders *b b* contained within the carriage, for the supply of the engines.

Mr. Wright's patent also includes a rotative engine, to be worked by air or steam, for propelling the carriage, which possesses no peculiarities demanding of notice in this place. The claim as to the application of the locomotive power, relates "to the propelling, drawing, or moving wheel carriages by the agency of compressed air, heated and used in the manner above described."

Mr. Clive, of Chell House, Staffordshire, took out a patent on the 1st of July 1830, for "certain improvements in the construction of, and machinery for, locomotive ploughs, harrows, and other machines and carriages," in which his chief objects appear to be twofold; *first*, the enlargement of the wheels on which the locomotive engine is supported and moves; and *second*, the enlargement of the radius of the crank, by which the rotation of the bearing wheels is produced. He considers that the bearing wheels might be varied according to circumstances, from about five to ten feet; and that the radius of the cranks should vary, according to the quality of the road or land, if employed for ploughing and harrowing, on which they are to be employed, from about eighteen to twenty-four inches.

This gentleman has, we believe, under the signature of *Saxula*, written many ingenious papers in the *Mechanics' Magazine*, in support of his theory, of the necessity of long cranks to the effective action of locomotive machines upon

common roads where the hills are considerable, or the obstructions of an abrupt nature. It will not accord with our limits to enter the controversy which has arisen upon the subject; but we will just briefly state, that from a cursory glance at the matter in dispute, it appears to us that *Saxula* considers the propelling power is exerted only in a vertical direction downwards; and that consequently any obstacles, such as a stone lying before the path of a wheel, at a greater distance from the lowest point of it than is the length of the crank, cannot by any power, however great, be surmounted. But on the other hand it is contended, that the propelling power acts uniformly throughout the circle, the same as if it were communicated directly by the piston of a rotatory engine.

A machine for "propelling carriages, vessels, and locomotive bodies," was invented and patented by Mr. Robert Crabtree, of Halesworth, in Suffolk, on the 4th of July 1829, the arrangement of which exhibits considerable mechanical skill; but the "principle" of its locomotive action having already been patented by Mr. Holland, as described by us in a previous page, Mr. Crabtree's ingenious modification will serve him but little; there is, however, no probability that either can be brought to compete with the machinery now in general use, on account of the greater degree of friction and liability to derangement, which numerous reciprocating levers must necessarily cause over the continuous rotatory movement. Mr. Crabtree thus explains the nature of his invention, in the introduction to his specification :—

"This invention consists in a machine or apparatus, or arrangement of mechanism, which is put in motion by means of a pendulum, or lever, acting upon two lever chains, or systems of levers, commonly called "lazy tongs," which, by their alternate expansive and contractive motion in propelling weights to and fro upon a main beam, balance, or lever, act by means of crank rods upon the cranks of paddle wheels in relation to vessels, and upon common wheels in relation to carriages, and upon toothed wheels, drums, straps, or bands, in relation to fixed machinery; and also by means of propellers in relation both to vessels and carriages, thereby producing progressive motion." Mr. Crabtree then proceeds, by means of drawings, to show the application of the invention to the propulsion of vessels; by one method he gives motion to a paddle wheel, and by another to propelling sticks, which are to push out against the ground at the bottom of a canal. Having described these navigating propellers, the patentee observes that, "it is obvious that the same mode of operation equally applies to the propelling of locomotive bodies upon land; for which purpose, nothing more is necessary than to apply the cranks to the axes of the carriage wheels, instead of the paddle wheels, or to propel them by the action of the main lever on the propellers."

The next candidate for the *Royal letters* appears to be Mr. John Moore, of the city of Bristol, to whom they were granted on the 30th of September, 1829, for "certain new or improved machinery for propelling carriages; also for propelling ships, vessels, or other floating bodies, and for guiding propelled carriages, and apparatus for condensing the steam of the steam-engines *after* it has propelled the steam-engine piston." The details of all these things would occupy too much space, and the quality of the inventions do not seem to require it from our hands; we shall, therefore, briefly notice the principal heads, and refer the reader to the inrolled parchment "for further particulars." The propelling is effected by a series of vibrating levers (actuated by a steam engine), and operating upon the running wheels of the carriage. The mode of "guiding propelled carriages" is by means of a vertical spindle carrying a pulley, around which a cord or chain is passed as well as around other pulleys, by which the frame of the fore wheels is placed at the required obliquity to the perch; and the mode of condensing the steam, after it has propelled the piston, is by allowing it to escape from the eduction-pipe, into a box opened to the atmosphere.

A patent for "certain improvements in steam boilers, and in carriages connected therewith," was taken out on the 2d of November, 1829, by Colonel *Viney of the Royal* Artillery; the specification of which informs us, th *consist, first, in* a boiler made up of a series of cylinders or tubes,

Description of the Carriages.	No.	Inclination of the descending Plane. Length in feet.	Inclination of the descending Plane. Height in feet.	Time of descent in Seconds.	Distance the Carriages run on ascending Plane before stopping.	Distance on both Planes, which the Carriages run before stopping. Length in feet.	Distance on both Planes, which the Carriages run before stopping. Height or difference of Level in feet.	Friction of the Carriages, including the resistance of the Air. In parts of weight.	Friction of the Carriages, including the resistance of the Air. In Pounds per Ton.
All these experiments were made with Mr. Winans' carriage No. 1, the weight of which was 16¼ cwt. loaded with stones to 4 tons, except No. 1 experiment, which was loaded with stones to 3½ tons. Wind-scare of carriage 10 square feet.	1	1.467	12	119.75	1166	2633	11.61	$\frac{1}{227}$	9.88
	2			116.75	1433	2920	11.33	$\frac{1}{256}$	8.75
	3	2.220	20	145.50	1865	4085	18.91	$\frac{1}{216}$	10.37
	4			145.00	1989	4209	18.81	$\frac{1}{224}$	10.10
	5			141.00	2711	4931	18.32	$\frac{1}{269}$	8.32
	6	2.604	24	149.50	2957	5561	22.15	$\frac{1}{251}$	8.92
	7			149.50	3221	5825	21.95	$\frac{1}{265}$	8.44
	8	3.364	32	176.00	3378	7241	29.30	$\frac{1}{247}$	9.06
	9			175.00	4013	7377	29.19	$\frac{1}{253}$	8.86
Mr. Winans' carriage No. 2, weight 13¼ cwt. loaded to 4 tons.	10	3.364	32	193.50	2486	5850	30.43	$\frac{1}{192}$	11.65
Mr. Brandreth's carriage No. 1, loaded with stones to 4 tons. Wind-scare of carriage 12 square feet,	11	1.467	12	123.25	1101	2568	11.66	$\frac{1}{219}$	10.21
	12			123.25	1115	2582	11.65	$\frac{1}{222}$	10.11
	13	2.220	20	147.00	1914	4134	18.87	$\frac{1}{219}$	10.23
	14			146.00	2025	4245	18.87	$\frac{1}{226}$	9.92
Mr. Brandreth's carriage No. 2, loaded with stones to 4 tons. Wind-scare of carriage 18 square feet.	15	2.982	28	177.50	2175	5157	26.66	$\frac{1}{193}$	11.58
	16			177.00	2448	5430	26.45	$\frac{1}{205}$	10.91
	17	3.364	32	185.00	2925	6289	30.18	$\frac{1}{208}$	10.75
	18			187.00	2648	6012	30.36	$\frac{1}{198}$	11.31
Mr. Stevenson's carriage, on springs, with 3-feet wheels, loaded to 4 tons. Wind-scare of carriage 13 square feet.	19	1.467	12	115.25	1744	3214	11.00	$\frac{1}{292}$	7.67
	20			115.25	1706	3173	11.03	$\frac{1}{288}$	7.79
	21	2.220	20	148.00	2427	4647	18.48	$\frac{1}{251}$	8.91
	22			142.50	2418	4638	18.46	$\frac{1}{251}$	8.92
	23			140.00	2517	4737	18.42	$\frac{1}{257}$	8.71
	24	2.604	24	159.50	3007	5611	22.12	$\frac{1}{254}$	8.83
	25			156.00	3008	5612	22.12	$\frac{1}{254}$	8.83
	26	3.364	32	177.00	3809	7173	29.36	$\frac{1}{244}$	9.17
	27			176.00	3839	7203	29.34	$\frac{1}{246}$	9.17

character. It was our intention to have inserted some drawings and descriptions of them, which we have been promised, but their non-arrival at the time we are going to press, obliges us to omit them. In lieu of them we shall here insert the inventors' *own account* of the construction and performance of their carriages, as given in evidence by them before a Committee of the House of Commons in 1831.

"*Mr. Nathaniel Ogle* examined.—Has (in conjunction with Mr. Summers) combined the greatest heating surface in the least possible space with the strongest mechanical force, so that they work their boiler at 250 lbs. pressure of steam on the inch with perfect safety. Their experimental vehicle, weighing about 3 tons, has been propelled from London to Southampton, and on the roads in the vicinity of Melbrook, at various speeds. The greatest velocity obtained over rather a wet road, with patches of gravel upon it, was from 32 to 35 miles an hour, and, on a good road, could have increased that velocity to 40 miles. They have ascended a hill with a soft wet bottom, rising 1 foot in 6, but at rather a slow rate. They have ascended one of the loftiest hills near Southampton, at 16½ miles an hour. Went from the turnpike-gate at Southampton to the 4-mile stone on the London road, a continued elevation with one very slight descent, at a rate of 24½ miles an hour, loaded with people. . . . . Their present experimental boiler contains 250 superficial feet of heating surface in the space of 3 feet 8 inches high, 3 feet long, and 2 feet 4 inches broad, and weighs about 8 cwt. The two cylinders communicate by their pistons, with a crank-axle, to. the ends of which either one or both wheels are affixed, as may be required One wheel is found sufficient, excepting under very difficult circumstances, and when the elevation is about 1 in 6, to impel the vehicle forward. Explosion is impossible, because the cylinders of which the boiler is composed are so small as to bear a greater pressure than could be produced by the quantity of fire beneath the boiler; and if any one of these cylinders should be injured, it would become merely a safety-valve to the rest. Have never, even with the greatest pressure, burst, rent, or injured their boilers; and they have not once required cleaning, after having been twelve months in use. Work usually at a pressure of 247 lbs. on the square inch, but they have worked at a greater pressure than that. Always travel with the safety-valve on the left; when the fire is only moderately good, the steam is always blowing off, even up the steepest hills. The fuel they use is soft and good coke; and there is no smoke. When going at 10 miles an hour, can stop within a less space than a carriage drawn by horses can. Their present carriage has only three wheels; so that the centre or guiding wheel rolls that portion of the road which has been hitherto cut up by the action of the horses' feet. The front wheel is 4½ inches broad in the tire; the two hind ones about 3 inches broader, that the carriage can draw double its own weight very well. Has seen nineteen persons upon it when going at the rate before mentioned. Thinks the injury done by steam carriages not one-half of that which is caused by horse-drawn carriages. Their wheels are cylindrical, with flat tires, and 5 feet 6 inches in diameter. Have never met with any accident; not one bolt, not one screw, has ever given way during twelve months, and under circumstances which would have destroyed any other carriage. They have, beyond all question, realized the power of propelling vehicles of any weight at any required velocity, and the remaining improvements they are engaged in regard slight details merely. Finds from experience that the larger the cylinder the better."

"*Mr. W. Alltoft Summers*, engineer, examined.—Has superintended the building of two steam vehicles; the lightest of the two weighed about 2 tons 10 cwt. Travelled in it when there were ten persons upon it, at the average rate of about 9 miles an hour, from Cable-street, Wellclose-square, London, to within two and a half miles of Basingstoke, when the crank shaft broke, and the carriage was put into a barge and sent back to town. This is not the carriage, however, to which the previous evidence of Mr. Ogle refers, nor is it upon the same principle, except that the boiler with which it was furnished has been transferred *to the vehicle* described by Mr. Ogle. When going to Basingstoke, *tried to increase the speed*, but were unable to do it, because the size of the

engines would not consume the quantity of steam generated. There were three cylinders, each 4 inches in diameter, and the stroke of the piston in each was 12 inches; in the carriage described by Mr. Ogle, the cylinders are 7¾ inches each, the diameter and the stroke of each is 18 inches. Has travelled in this new carriage 15 miles per hour, with nineteen persons on the carriage. . . . . Has no doubt of its being able to carry 3 tons at the rate of 10 miles an hour, exclusive of its own weight; and, after certain improvements which they have in view are completed, feels assured that much greater weights may be carried at that rate. Has never tested this by experiment, but grounds his opinion on having seen the steam blowing off at both safety valves with tremendous violence when travelling at the rate of upwards of 30 miles per hour. Has continued travelling at the rate of 30 miles an hour 4½ miles very frequently, and could have continued longer had they not required a fresh supply of water, the tank not being quite large enough. Since the last improvement in the furnace, they have never found any difficulty, when the fire is in good order, in travelling over the worst and most hilly roads. On arriving at the brow of a hill, they throttle or wire-draw the steam, in order to check the velocity of the engines; and when they find the hill is so steep that the carriage would run faster than they wish, they attach two drags to the hind wheels, and with the foot they press on one drag, or both, as may be required, and by that means regulate the velocity of the carriage. The drag does not, however, prevent the wheel revolving; it consists of a kind of iron band, or strap, which goes round a portion of the tire of the wheel, and the power of breaking is multiplied by levers to a very great extent. Were the carriage to go at the rate of 5 miles an hour only, instead of 10, it would be able to carry a much greater weight than 3 tons; cannot exactly say how much. Has used water of every description, but has never found the boiler in the least encrusted. Every time, after arriving at a journey's end, they open a cock communicating at the bottom of the boiler, and perhaps it may be that they do not give the extraneous matter time enough to rest. Proved the boiler before it was put into the steam carriage at 364 lbs. on the square inch; it will support 740 lbs. Work usually at a pressure of from 240 to 260, which they find more economical than any other. The surface of iron exposed to the fire and heated air is 245 superficial feet; the weight of the boiler is 8 cwt. 2 qrs. The iron is about one-tenth of an inch thick. Thin boilers last longer in proportion than thick ones, because the heat passes sooner through into the water, and has not time to act upon the iron. The passengers are placed in front and the middle of the vehicle; the boiler entirely behind the body of the carriage and the passengers. Has never had any accident from horses being alarmed; the noise is not so great as that of a vehicle drawn by horses. Considers the mode they have adopted of disposing of the waste steam preferable to that of Mr. Stephenson. Instead of blowing it into the chimney, in order to cause a draft, they have a fan or blower, which is driven by the engines when in operation, and this gives intensity of heat in the furnace. The waste steam from the engine goes into a double casing round the furnace; they admit a small portion underneath the fire-bars of the grate, and allow the remainder to expand itself into the double casing, after which it comes over the top of the fire and escapes in the form of invisible vapour. Finds this better than throwing the steam direct into the chimney to produce a draft; because where this is done, the aperture must be so much diminished that the waste steam is choked in escaping from the engines, and produces a greater loss of power than is required for working the fan. Finds that, when travelling on a paved road, and that of a rough description, they do not consume more than the fourth of the steam they do on a soft gravelly road. The steepest hill they have ever ascended was 1 foot in 6; that was the hill at Shirley, for a distance of about 200 yards. Both the wheels were in gear at the time, and there was not the slightest symptom of their slipping. Ascended it at a velocity of nearly 5 *miles an hour,* with fourteen or fifteen persons on the carriage. Can stop the *vehicle within* a distance of 12 feet . . . . The engine is calculated at 20-horse *power.*"

On the 19th of July, 1830, a patent was issued to Messrs. Rawe and Boase,

of Albany-street, London, for "improvements in steam carriages and in boilers; and a method of producing draft." The specification of their patent contains a description, with drawings, of a complete locomotive carriage for the common road.

The boiler is entirely composed of stout wrought-iron tubes, having an internal diameter of an inch and three-quarters. The length or number of the tubes are, of course, arbitrary, depending upon the capacity of the boiler; in the instance before us, the boiler consists of 12 tubes; each individual tube is bent into a spiral figure of three turns, which are of equal diameter or breadth.

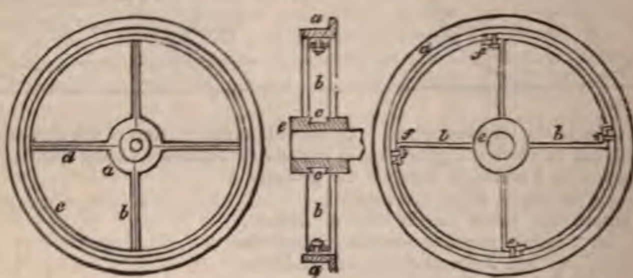
The first spiral tube thus formed, would contain within its coils a cylinder of 1 foot in diameter; the second spiral tube is curved in a parallel line to the first, but of about four inches greater diameter, so that it will lie outside of the first, and exactly circumscribe it, leaving between the two a space of about an eighth of an inch. Each successive tube of the whole twelve is curved in like manner, the coils of the whole being equidistant, but the diameter of each separate spiral is in succession 4 inches greater than the preceding one. By this arrangement, it will be perceived, is produced a spirally inclined plane of tubes, which are inclosed in a cylindrical case; at the bottom of this the furnace is situated, about one foot beneath the lowest ends of the tubes, and occupying the whole area of the circle. The upper ends of the range of tubes open into a strong receptacle, being secured in both in a thoroughly steam-tight manner, by means of hollow screwed bolts, with nuts and collars, in the following manner:—A small tube is fixed to the end of each of the spiral tubes, and each of these small tubes is passed through the receptacle, and the shoulder formed by the ends of the large tubes are, with suitable packing interposed, brought, by means of screwed nuts, close up to the side of the receptacles: these receptacles are strong tubes, elliptical in their transverse section, and flattened at their conjugate axes, for the convenience of screwing up firmly. For removing the deposit from the water at pleasure, solid plugs are screwed into the ends of the small tubes, which can be taken out whenever required for that purpose. By the arrangement described, it will appear that the heat from the circular fire, about 4 feet 6 inches in diameter, impinges vertically upon a similar extent of the boiler above; thence ascending the current winds round between the coils of the inclined plane of tubes, which forming the flues as well as the boiler, the heat is abstracted in its progress, by an economical consumption of fuel, through the small spaces between the concentric spirals, the heated air and flames escape out of the spiral current, and by completely enveloping the tubes, materially augment the production of steam. To increase the combustion, an exhausting fan-wheel is placed immediately over the boiler, revolving on a vertical spindle, which passes through the centre of the boiler and furnace, and is actuated by suitable gear put in motion by the ngine. To avoid the inconvenience that might be experienced from the escape o' the gaseous products of combustion upwards, the patentees propose to dispense with the use of a chimney, and by enclosing the upper part of the fan-wheel, and surrounding the boiler with an external casing, cause the vapours to pass downwards against the ground, underneath the vehicle. The patentees likewise propose to force a mixture of highly rarefied steam and heated air through the ignited air in the furnace along a pipe, that makes several coils around the ash-pit, before entering a chamber immediately beneath the great bars; into this chamber by another pipe is also introduced steam, the mixed air and steam from this chamber proceed through a series of short vertical tubes and the hollow bars of the grate, and thence through certain perforated nozzles into the fire in minute jets.

In the centre of the boiler is situated the float chamber; this is of a cylindrical form as far as the boiler extends; but the lower portion, which passes through the furnace, and the bottom of the grate, is tapered off to a reduced diameter, making the figure of an inverted frustrum of a cone; to the lower end of this vessel is screwed an iron cap, and the upper end is closed in like manner; passing through both these caps and the mindle of the chamber, is a straight piece of tube fixed "stanch" to the caps by screwed nuts and packing. This

the wheels instantly to assume the same position, and make the deviating course required. It is obvious that a common axis would not effect this operation; and there is, perhaps, no better mode of attaining the object of the patentee, than the one he has adopted. The ball, it will be seen, has sufficient play by letting one side turn against a conical piece *e*, formed spherically on its inner edges, and bringing out a boss *f* from the outer plate, having at its end a concavity, which fits the sphericity of the ball; and as these opposite cavities may be made to recede or approach, by means of the screw-bolts *g g*, which connect them, they thus afford ready means of adjusting the surfaces, so as to make the axis work pleasantly.

Some improvements in the construction of wheels for railway carriages were patented on the 31st of August, 1830, by Mr. Wm. Losh, of Bentom House, in Northumberland, a gentleman whose experience and knowledge in matters of this kind entitles his suggestions to the attention of the public.

Fig. 1. *Fig.* 2. *Fig.* 3.



The nature of this invention will be at once understood from inspection o *Figs.* 1 and 2, where *a a a a* represent the tire and flags of a wrought-iron railway wheel; *b b b b* spokes which are to be made dove-tailed at one end, and cast into the nave *e*, as shown in section at *c c*, *Fig.* 2. The other end of the spoke has a right angular crank bend, as shown at *f f f*, *Fig.* 1; being carried round the circle to the next spoke; and thus each spoke and its adjoining felloe are made of one piece of iron. By means of the crank bend at the end of the spokes, one felloe is permitted to pass over the end of another, and at this double part they are securely fixed together by strong screws, as shown by dotted lines. The tire, which is formed in passing finally through the rollers at the iron works, with a recess for the felloe, and a ledge to keep the carriage on the railroad, as represented at *a a;* and it is to be heated and fitted on the wheel in the usual manner, that it may contract and firmly grasp the wheel when it contracts in cooling. The ends of the spokes, too, must be made hot before the nave is cast upon them, that the junction of the two metals may be the more perfect. It is stated that it may be sometimes found more convenient to weld several pieces of iron together than to bend one piece twice at right angles. It is likewise stated that the spoke may be sometimes with advantage welded on the middle of a piece extending along a ring constituting the felloes in both directions.

Messrs. W. G. and R. Heaton, of Birmingham, have built several steam carriages which have operated with various degrees of success in their own neighbourhood. Their patent is dated the 5th of October, 1830. The complicated nature of the machinery exhibited, in the specification of this patent, renders it quite impossible to make it fully understood without a series of drawings, and a detailed description, for which we cannot find room in this article. We shall therefore confine ourselves to an outline of the methods which the patentees adopt to accomplish the object they have in view that of idance of a locomotive carriage, and the management of the steam apparatus,

that the power and speed may be accommodated to the nature of the road, the quantity of the load, &c. For the purpose of steering the carriage, a vertical spindle is placed at some distance before the axle of the front wheels, and on its lower end a small drum is fixed Around this drum is coiled a chain with its middle fixed upon the drum, and its ends made secure to the front axle at a considerable distance from the middle, so that the chain and axle may form a triangle with the drum, situated at the angle opposite the longest side. The other end of the vertical spindle is connected with a frame situated in front of the coachman's, or rather the steersman's seat; and here is fixed upon the spindle a horizontal beveled-toothed wheel. Over this wheel an axis extends, terminated in two crank handles proceeding from the axes in different directions, so that one will be down when the other is up; and upon this axis is fixed another beveled-toothed wheel taking into the first. Now it is evident when these wheels are turned in one direction the right-hand fore wheel of the carriage will be advanced, and the coach will be turned towards the left, while if they be tnrned in the other direction, the left-hand wheel will be advanced, and the carriage will be turned towards the right. This plan of steering will be immediately recognised by our readers as the same with that adopted by Mr. James.

The driving wheels, or those to which the power of the engines is to be applied, are connected with the axle by means of a pair of ratchets furnished with a double set of ratchet teeth and a reversing pall. By this contrivance one wheel can be advanced or backed while the other is stationary, or moving in a contrary direction; an arrangement which becomes necessary in the act of turning and backing. The means of acting upon the reversing pall is brought within the reach of the steersman by means of a set of connecting rods and lever.

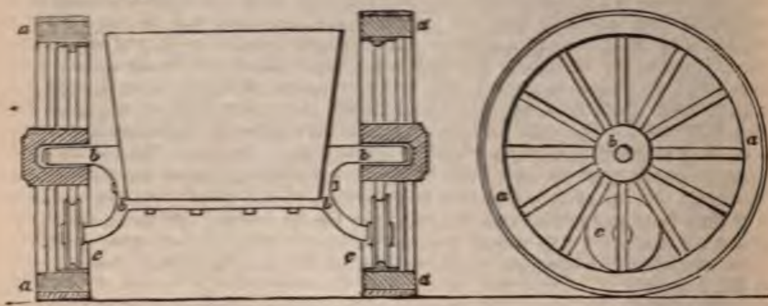
Motion is communicated to the driving wheels by a double set of spur wheel gear, arranged to give different powers or velocities, by having both a large and a small wheel fixed on the driving as well as the driven axis. By shifting the large wheel on the driving axis into gear with the small wheel or the driven axis, speed is obtained; and by shifting their relative position till the small wheel on the driving axis comes into gear with the large wheel on the driven axis, power is obtained at the expense of speed. These two axes are kept at the same distance from each other by means of connecting rods, notwithstanding the relative position may be changed by the motion of the carriage on rough roads.

These patentees do not claim novelty in any one of their arrangements in a detached form, but only the combination of the whole, as they have described them in their specification. A principal merit of the arrangement seems to be, that all the adjustments are brought within reach of the man having the guidance of the carriage.

An American inventor communicated to Mr. Gillet of Birmingham a new modification for a carriage or waggon, for which the great seal was obtained on the 4th of November 1830. The invention consists in the adaptation of the wheels of carriages to what has been called a *perpetual railway*. It is formed by a circular rib or rail placed round the interior of the felloe of the wheel, upon which circular rib a small wheel with a grooved periphery is intended to run, which small wheel bearing its portion of the burthen of the carriage, by running upon a smooth even surface, it is presumed will greatly facilitate the progress of the carriage, when the larger or running wheels pass over heavy or uneven ground. In the annexed cuts are represented by *Fig.* 1 a side elevation of the large running wheel, and the situation of the smaller one that runs on the inside of its felloe; and *Fig.* 2 shows a sectional end view of two such wheels, with their little companions, applied to a tram waggon; *a a* is a large wheel of a common description, and turning loosely (with considerable play) on the axles *b b*, which is made in the form represented to obtain considerable strength, and having strong curved arms which form the axes of the little wheels *c c;* these are grooved on their peripheries to fit the circular edge railways *d d*, fixes inside the felloes of the large wheels. The patentee

states that "although the running wheels will pass over the ground as in ordinary carriages, yet the weight of the carriage and its burthen is borne by

Fig. 2. *Fig. 1.*



the small wheels, and consequently, through the large running wheels should pass over soft, wet, or uneven ground, the wheels which actually bear the weight, and upon which the carriage travels, move upon a smooth, even perpetual railway on which there is little or no resistance." The patentee, however, omits to notice the obvious fact, that the little wheel does not assist the great wheel out of the mire, but rather tends to sink it deeper by reason of its weight and the heavy incumbrances it entails, to say nothing of the extra-friction caused by an unnecessary increase of rubbing surface in the multiplied axles.

"This contrivance," the patentee adds, "is equally applicable to the wheels of any kind of carriage, and is only shown in the drawing as adapted to a tram waggon for the purpose of illustrating its peculiar construction and adaptation." A similar invention was patented by Mr. George Hunter of Edinburgh in 1826.

Messrs. Bramley and Parker, of Moulsley Priory, in Surrey, received patent grants for their improvements in locomotive carriages, applicable to rail and other roads; which we shall very briefly describe, as they do not appear to us likely to become of much practical utility in the present state of the art of locomotion. The improvements contemplated are of three kinds. The first consists of a carriage to be propelled by horses, working a pair of tread-wheels; the second of a light carriage to be propelled by one or more men, resting with their chests on cushions, and communicating motion to cranks by pushing out with their feet, as in the act of swimming; the third consists of an arrangement for preserving the box of the wheel on the end of the axle. The latter plan is very deficient in novelty; the other two are modifications of many similar propositions to obtain mechanical force from animal agency; but we cannot agree with the ingenious patentees that they are "certain improvements." The *details* of these inventions, with the amusing illustrative drawings, may be seen at the "Six clerks' office" in Chancery-lane.

Mr. Gordon, in his Treatise on Locomotion, page 58, states, that in the beginning of the year 1831, the directors of the Monkland and Kirkintilloch railway, near Glasgow, directed their engineer to make out a plan and specification of two locomotive engines, able to drag 60 tons gross weight at the rate of 4 or 5 miles an hour. This was done accordingly, and the engines contracted for by Messrs. Murdoch and Aitken engineers, Hill-street Glasgow, who brought the first upon the railway the 10th of May, and the second upon the 10th of Sep-mber the same year. Both engines travelled several miles upon the railway; first day they were brought out of the yard at Glasgow, and have since, ng a course of eighteen months' trial, proved themselves the most efficient es of the kind ever made in the kingdom, being capable of taking 10 tons

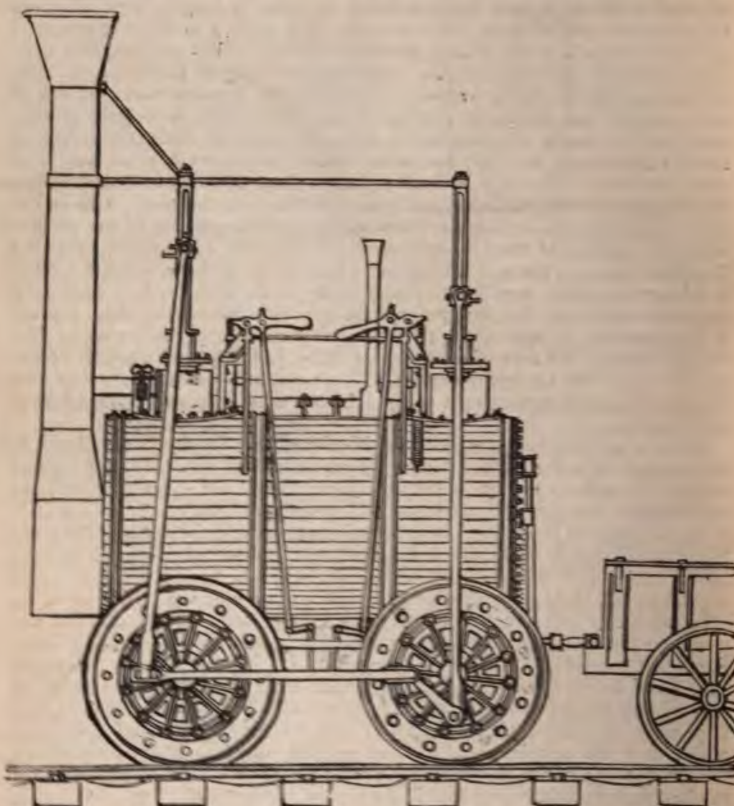
more on a level railway, than any engine yet made of the same size of cylinder with a pressure of 50lbs. to the square inch upon the boiler. The line of railway on which these engines daily travel is one of the very worst description for the effectual working of such engines, being 8½ miles in length, with numerous abrupt curves and descents. The descents are 1 in 50, 1 in 116, 1 in 120, &c.; the curves are of a radius of 344, the arch 335 feet; radius 400 feet, arch 650; radius 700 feet, arch 545 feet, &c. The descents being in favour of the load, the bringing up the empty waggon is considered the heaviest work, yet one of these engines has frequently returned from Kirkintilloch, where the railway ends, with 50 empty waggons, in the ordinary course of trade, the weight of which being about 60 tons; but when loaded, they carry a gross weight of about 200 tons. The daily load of engine, is from 20 to 50 loaded waggons, according to the circumstances, and trade occurring on the road. One of the great improvements on these engines is, the metallic packing of the pistons, which are the first of the kind ever used, and of such a description, that the 2 engines have not cost one shilling in 18 months for packing, and use neither grease nor any other unctuous substance whatever for the cylinders, since their commencement: another, and perhaps the greatest advantage of these pistons, is the economy of labour, the reduction of friction, and the saving of fuel thereby effected, the area of the fireplace being just 4 feet, or one-half of the size of that in the Liverpool engines. These pistons are each formed of two iron rings in three segments; a wedge between each segment is pressed by a spiral spring.

In the report by the directors of the Monkland and Kirkintilloch railway, to the proprietors at their general meeting on the 1st of February, 1832, these engines are noticed in the following manner:—"Your committee have, as mentioned in last year's report, built two locomotive engines, which have been in employment on the railway for nearly six months, and the whole of the trade from the collieries to Kirkintilloch is now drawn by these machines. The committee, after much consideration, devolved the whole form and plan of these engines to Mr. Dodds, the superintendant. It was strongly urged by some of the proprietors that these engines should be got from England, and that the improvements of the engines adopted on the Liverpool railway should be introduced in constructing those for the Company. On inquiry, however, no certain data could be obtained whereby to calculate what would be the expense of maintaining in repair such improved engines; and it was also ascertained that they were very liable to be deranged, when working at the high speeds for which they are calculated. For these reasons, the committee devolved on Mr. Dodds the entire responsibility of the planning of the engine, and the result of their confidence has been in the highest degree satisfactory. Mr. Dodds, in his plan and specification, adopted none of the recent improvements, except that of the copper tubes, suggested by Mr. Booth, giving however a great additional strength to these tubes. The contract for making the engines was taken by Messrs. Murdoch and Aitken, Hill-street, Glasgow, and the committee are satisfied with their performance, except as to the time taken by them in furnishing the second engine. This is no small praise, considering they were the first locomotive engines constructed in Glasgow.

"The excellence of Mr. Dodds' plan and specification, so far as several months' trial can be considered a proof, is most satisfactory, as the engines have never been one day off work, except on two occasions, when injured by the malice or carelessness of certain waggoners on the road. On the other hand, the engines procured from England, by an adjoining railway company, (the Garnkirk,) have been repeatedly taken off the road, on account of needing repairs, &c. Since the date of this report, these engines have done all the trade to Kirkintilloch, and other places, for another year, and have not been off one day, or employed a single horse to assist them. These are facts, and the best criterion whereby to judge of their real performance, or to make comparison between them and other railway locomotive engines.

The cut on the following page is a view of this engine, with the tender attached. The connecting-rod between the two wheels has a ball and socket-

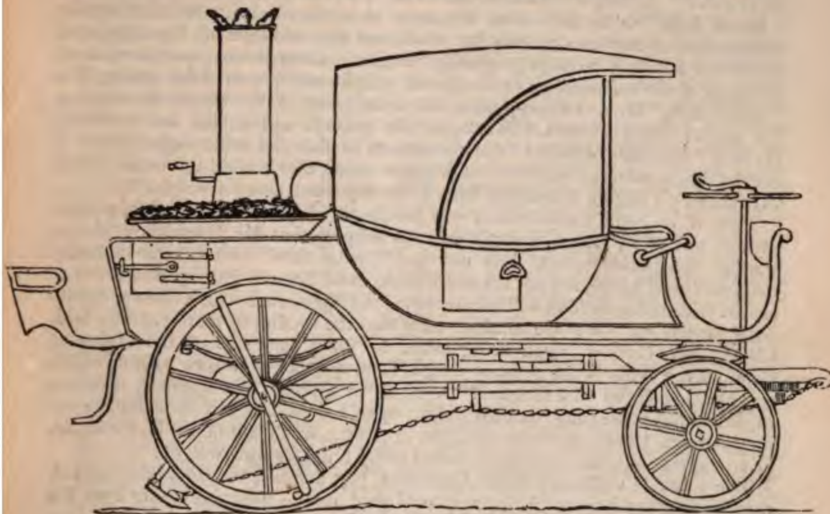
joint at each end, making universal joints. The wheels have a play of about one inch, to allow for turning in the above curve. The cylinders are 10½ inches



diameter each, and the stroke is 2 feet; pressure of steam, 50 lbs. The average speed of these locomotive engines, is now 6 miles per hour; the regulation is 5 miles per hour, but they sometimes even double the regulated speed.

"In February 1831," observes Mr. Gordon, "Mr. Gurney having completed three steam carriages for Sir Charles Dance, that gentleman commenced running one regularly on the road betwixt Gloucester and Cheltenham, and continued so to do, constantly and successfully, for four months, until he (disgusted with the opposition) withdrew his coaches." These steam carriages were employed as *drags*, to draw after them the passengers contained in a light carriage of the omnibus kind. One of these *drags* has been figured in a lithographic plate, by Mr. Gordon, of which the following cut is an outline; from this, it appears that the "indispensable" *separators*, are entirely dismissed. The proportions of this machine give it an elegant and a light appearance. Its weight, however, having been stated to be only two tons, it was brought to the test of a weighbridge at Cheltenham or Gloucester, and found to be *three* tons. This fact is of little importance, except as it affects calculations founded upon such erroneous data. The public mind has indeed been so abused by contradictory statements on this, as well as other points respecting these machines,

that it is scarcely possible to extract the truth. Before the Committee of the House of Commons in 1831, Mr. Gurney stated that his first carriages weighed



four tons each; but this fact did not prevent his "scientific friend," who had "scientifically investigated" it, from stating in the "Times" newspaper, that "*the whole carriage and machinery weigh about* 16 *cwt., and with the full complement of water and coke from* 20 *to* 22 *cwt.*" Mr. Gurney further states in his evidence—"*The carriage* which ran between Gloucester and Cheltenham weighs (by a letter from a magistrate, produced to the Committee,) nearly three tons; it ought to weigh only 45 cwt.; if it weighs three tons, there is extra weight, of which I know nothing. *Those carriages* at Gloucester were built principally under the superintendence of *another person.* I think it is *possible* to reduce the weight considerably as improvements go on." We must here make a brief digression, to state that we understand the three carriages were built and painted exactly alike, so that the public should not know how often they were changed; hence, we have recorded in print by our contemporaries, "a tabular view of 315 journeys performed by a steam carriage." The "another person," alluded to by Mr. Gurney, was that very able engineer, Mr. Stone, who was Mr. Gurney's foreman, and superintended all the products of his manufactory. As respects the matter of the weight, which Mr. Gurney thinks it *possible* to reduce, we will just place before the reader, the evidence of Mr. Wm. Crawshay, jun. on this point. In the "Cambrian" newspaper, and dated Cyfaithfa Iron Works, 18th March, 1830, this gentleman says to the editor of the "Cambrian:"—

"Sir,—As I have reason to expect that a report will be sent to you of the arrival of Mr. Gurney's steam carriage at my father's works at Hirwain, and of the experiments made of its powers on a railroad there, I think it better to inform the public (now so much interested in the subject of steam conveyance) through your medium, of the *actual facts* that have been witnessed in the experiments made, and under what circumstances."

"Mr. Gurney, at my most earnest request, while I was in London three weeks since, consented to bring one of his steam carriages which had been built and adapted for drawing coaches on turnpike roads, to try her powers on our new railroad on Hirwain Common." Mr. Crawshay then proceeds to state that "he had considerable difficulty in persuading Mr. Gurney to accede to his wishes;" *however,* the latter gentleman at length consented to gratify *the interested public;* and the engine was sent from London to Cyfaithfa by horses, and

there fitted with *cast-iron wheels*, and otherwise adapted to the railroad. Thus prepared, "the engine, with water and fuel," Mr. Crawshay says, "weighed *thirty cwt.!*" so that if we admit Mr. Gurney's evidence, and Mr. Crawshay's "actual facts" to be both true, we must be prepared also to believe that the substitution of cast-iron wheels for wood, and the addition of the charges of water and fuel to a carriage previously weighing about 3 tons, must have been the cause of the extraordinary reduction of weight mentioned. After stating this "actual fact," Mr. Crawshay makes out a statement of the weight attached to the engine being 20 tons. 8 cwt. 2qrs. (the pounds and ounces are omitted.) Having "faithfully detailed" the particulars of this and other experiments of greater magnitude, this eminent iron-master states, that "in all the cases named Mr. Gurney's engine has drawn from 15 to 16½ times its own weight."

Now, if we could exclude from our minds all idea of the foregoing phenomenon, and were, for argument's sake, to suppose that Mr. Gurney's evidence was on this point correct, does not the "actual fact" data become actually fictitious? and hence, are not the deductions actual farces? Perhaps Dr. Lardner or Mr. Alexander Gordon will help us out of the dilemma in which these accounts have placed us. We are anxious only that the unalloyed truth shall be told. (*Note.*—Mr. Gurney, upon being asked by the Committee of the House of Commons, "What is the greatest weight in proportion to its own weight, which any carriage draws on a railroad?" replied, "A carriage was originally *supposed* to draw only three times its own weight upon a railroad; but in some experiments which I made in Wales with Mr. Crawshay, of Cyfaithfa Castle, we found, in an experiment, that a carriage draws *thirty* times its own weight!")

The valuable testimony of Mr. Crawshay, just noticed, was so highly prized, that we find another was boastingly published in the following year, from the same gentleman, and addressed to Sir Charles Dance. It is dated, Cyfaithfa Iron Works, 23d February, 1832. We regret that our space will only allow us to give the following brief extract, which, however, relates to the main point:—

"As, however, facts of past performances of any kind are more satisfactory than anticipations of the future, I beg to state to you, that in the past twelve months, between the 1st day of January 1831 and the 1st day of January 1832, the locomotive engine which I bought of Mr. Gurney, weighing only thirty-*five* hundred-weight, including every thing whatever belonging to it, with water and fuel in a working state, conveyed 42,300 tons of coal, iron-stone, and iron, exclusive of the carriages on which they were drawn, the distance of 2¼ miles upon our rail at Hirwain, in journeys of from 20 to 30 tons, as suited our convenience; during which time the entire consumption of coal was 299 tons, which, at 3*s.* per ton, amounts to 44*l.* 17*s.*; the wages of the engineer 52*l.*, and those of the boy 15*l.* 12*s.* together, exclusive of the trifling repair of the engine, and the oil and other little matters required for its use, 112*l.* 9*s.*, or less than one farthing per ton per mile, for the goods conveyed; and I must not omit to observe to that had there been nearly double the work to do on this road, the engine would have done it with little or no increased expense, as she was invariably working idle for the purpose of keeping the boiler full, about one half of her time."

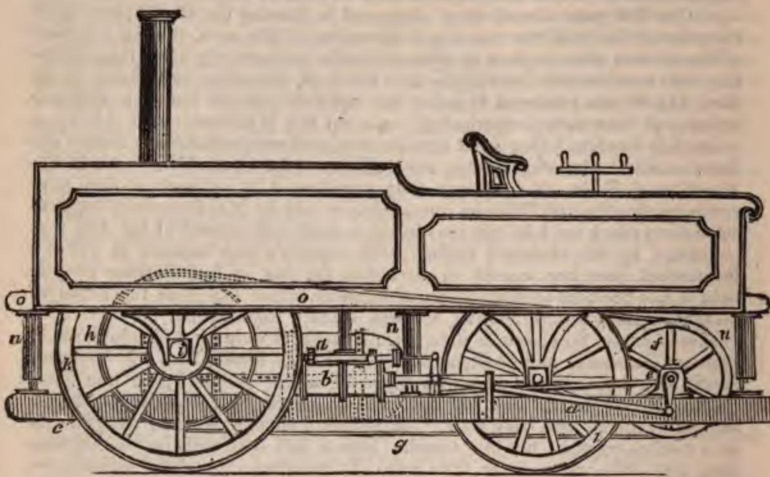
To readers who do not calculate, this *statement* appears highly flattering; but a very little investigation will, we think, show it to be the reverse. Let us first look to the horse-power exerted by the engine: if we take the usual estimate of horse-power at 150*l.* constant force, at 2½ miles per hour, and estimate the resistance of the Hirwain railway, which is upon a dead level, and has been formed since that of Manchester and Liverpool, at the same resistance as that on the latter, which is $\frac{1}{240}$th of the insistent weight, we have $150 \times 240 \times 8$ hours $\times 310$ days $= 89{,}280{,}000$ lbs. $\div 2240 = 39857$ tons drawn by one horse in the year. If, however, we take the estimate of a horse's power, made by Mr. Bevan, (whose results are much more entitled to confidence than those of any other experimentalist, on account of the much more extended scale of his experiments,) we shall have 163 lbs. as our datum for a horse's power, (being the mean force exerted by each horse out of 144 at ploughing;) and this increased estimate we find makes the number of tons drawn by one horse's power

43,311 in 310 days of ordinary work. This powerful engine, therefore, did the work of one of Mr. Bevan's horses. Let us next examine its economy in the consumption of fuel, as compared to other locomotive engines. Mr. Crawshay says that 299 tons of coal were consumed in drawing the 42,300 tons; as to the price of the coals, the wages, and the waste by idle work, the same circumstances attend other engines on other railroads, and can only affect this calculation by unnecessarily mystifying it; we shall, therefore, not notice them. Now 42,300 tons conveyed 2½ miles, are equal to 105,750 tons conveyed one mile; and from some experiments made on the Manchester and Liverpool railway, it was found that about ten ounces of coal were sufficient to convey one ton one mile. But after making every allowance for waste, Mr. Wood, in his *Treatise on Railroads* (see page 405) considers 1 lb. adequate to each ton; consequently, the 105,750 tons conveyed one mile by Mr. Crawshay, ought to have been taken (at 1 lb. per ton) by 47 tons of coal, instead of the 299 tons consumed by Mr. Gurney's engine. Mr. Gurney's *improvements* in railway locomotion, therefore, consist in rendering the cost of fuel six times greater than it was previous to this notable experiment, which has gone the round of all the journals, and, we believe, hitherto, without comment!

The friends of Sir C. Dance state, that his carriages were stopped from running between Gloucester and Cheltenham owing to there having been 9 or 10 inches depth of rough stones laid across the road, at the instigation of the horse coach proprietors; and that, although the power of the engines was sufficient for fair average roads, they were "not powerful enough to travel satisfactorily on a road so treated; but Sir Charles Dance had seen sufficient to convince him, that little more power than what he possessed would be sufficient to overcome all the obstacles of common roads; he did not therefore desert the cause, but continued his inquiries and experiments, daily becoming better acquainted with his subject, and yet not so well satisfied with himself, but that he became desirous of consulting *practical* experience, and this brought him acquainted with Messrs. Maudslay and Field, whose practical skill, aided by Sir Charles Dance's information, enabled them to fit up one of the old carriages in such a manner, as to show results far greater than any thing which had before been accomplished by steam carriages upon common roads." This alludes to a journey to Brighton, the particulars of which we cannot insert, but they are given by Mr. Gordon in his Treatise. The connexion between Sir Charles Dance and the engineers just mentioned led to the taking out of a patent in 1833, which we shall notice in its proper place.

The specification of the patent granted on the 4th March 1831, to the Messrs. Napier, of London and Glasgow, shows, that those gentleman, notwithstanding their unquestionable ability as practical engineers, were but indifferently informed upon the progress of invention in locomotion. They describe their improvements to consist, "First, in communicating the power of the engine or engines for propelling the carriage to the wheels, by means of a belt, strap, or band, made of leather or *any other suitable material*, and which belt, or band, works upon two pulleys or drums, the one fixed upon a shaft connected with the engine or engines, the other fixed upon, or connected with, the axle or wheels of the carriage; more than one of which belts may be used if necessary. This will be better understood by reference to the cut on the next page. *a* is a horizontal steam boiler, with an hemispherical end; at *b* are the two cylinders of the engines working horizontally, and fastened upon the boilers; *c c* is the framing of engines, which is also fastened to the boilers and engine cylinders; *d* connecting rod of engine; *e* the crank shaft of engines, upon which is fixed the pulley or drum *f*, from which pulley the strap *g* communicates the power of the engine to the pulley or drum *h*, which in the present case is fixed on the middle of the wheel axle *i*; *k k* the hind wheels of carriage; *l* fore wheel of carriage, which turns on a circular plate for the purpose of guiding the carriage on the common roads. The boilers and engines being firmly fastened together, thus forming one entire piece, is suspended by springs *n n n*, from a frame work *o o*, resting upon the wheel axles of the carriage, and having no connexion with the said carriage or frame-work, but by

springs, and belts or bands. It is thus freed from the severe jolts and shakes of the road, which are so injurious to machinery."



The above arrangement is applicable to common or turnpike roads, an may be easily altered to be suitable for railways. The patentees lay no claim to this or any other arrangement of the parts of the machinery, but merely to the application of the belt, straps or band, made of leather, or any other suitable material, with either cylindrical or conical pulleys or drums, to communicate the power of the engine or engines to the wheels of carriages.

The specification likewise describes some varieties of a cylindrical boiler made with a longitudinal central flue, terminating in an hemispherical chamber or cap, covering the whole of the end of the boiler; from this chamber the heated gases are compelled to return through a series of smaller tubes to the front end of the boiler, whence they are conducted to the chimney.

We have already described, at page 109, a patented improvement by Mr. Robert Stephenson on the axletrees of railway carriages. At the period we are now treating of, another invention, from the same celebrated engineer, presents itself to our notice; it is dated the 11th of March 1831, and is entitled, "Improvement in the axles and parts which form the bearings at the centres of wheels, which are to travel upon edge railways."

In order to produce rotation in the wheels, and consequently progression of locomotive carriages, it is necessary to fix the wheels on the ends of the axles, and when this fixture is effected in the usual manner, the weight of the carriage and its contents is supported by concave bearings resting on the upper surfaces of the cylindrical ends of the axles, and hence arises a difficulty in keeping the rubbing parts constantly lubricated, as the oil supplied to the parts in contact will have a tendency to escape by its gravity to a more open space on the lower sides of the axles; and the consequence of this is, considerable waste of oil, with an imperfect lubrication.

To remedy this, Mr. Stephenson employs for each pair of wheels, a double axle, consisting of a hollow casing, on the extremities of which the wheels are firmly fixed, and a solid axis passing through the hollow casing, and supporting on its ends the weight of the carriage, through the medium of hollow bearings attached to springs of the usual construction, which connects the bearings with the side rails of the carriage, placed necessarily on the outside of the wheels. Thus the supporters or wheels being fixed to the concave parts of the bearings, and the supported weight or carriage being connected with the convex or solid

part of the bearings, the oil will have a tendency by its gravity to accumulate on the rubbing parts, and thus combine a perfect lubrication with an economical supply of lubricating material.

The solid axles are made thickest near their extremities, so that the parts which pass through those portions of the hollow axles which are fixed into the naves of the wheels, and at the same time the apertures of the corresponding parts of the hollow axles, are diminished, both being turned perfectly cylindrical, that they may be fitted together with facility, and come into contact only where the bearings are intended to take place.

In September 1831, Mr. G. H. Palmer, of Manchester-street, Grays Inn Road, took out a patent for a variety of improvements appertaining to locomotion, which we shall proceed to notice.

The abstract parts of the engine and boiler which he claims as being novel either in principle, or as regards their peculiar modification, are,—

First, The self-regulating blast apparatus, by which the quantity of fuel to be ignited in a given time is governed, in order to insure the generation of a volume of steam, suited precisely to all the variable speeds and powers of the engine.

Secondly, The steam calorific self-adjusting apparatus, which acts in conjunction with the blast regulator, and is so contrived as to lift the weight from the lever of the safety valve, and permit the steam to escape from the boiler should the aforesaid apparatus fail of instantly checking its evolution.

Thirdly, The self-acting safety apparatus, by which the security of the boiler is insured, should the apparatus for supplying it with water fail in its effect, so that in the event of the water in the boiler being reduced below a determined level, the process of combustion will be instantly suspended, and the boiler protected from injury.

Fourthly, Making the products of combustion evolved from the furnace escape into the atmosphere below the level of the furnace bars, which will most effectually prevent the admission of atmospheric air into the furnace, excepting that portion which the blast and calorific regulating apparatus permits the blowers to project upon the fuel undergoing combustion.

Fifthly, The pipes leading from the opposite ends of the horizontal part of the boiler, are designed to convey the water (which must be distilled) most remote from the direct action of the furnace, to replace that portion which may be carried to the upper part of the boiler by the great volume of steam generated between the two concentric cylinders.

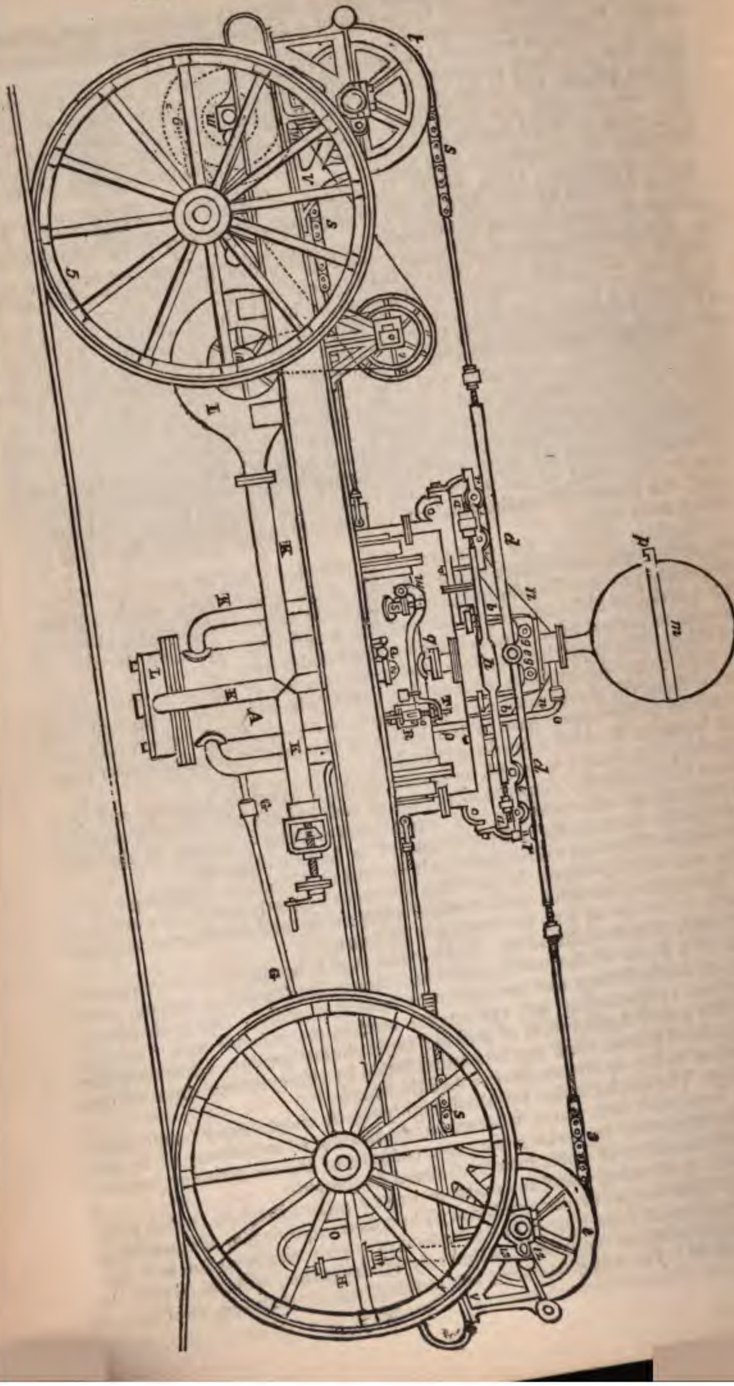
Sixthly, To insure a length of stroke in high pressure engines, and that without increasing the diameter of the piston rods beyond that which is required to withstand the alternate tug and thrust; and without resorting to the very objectionable short stroke and piston rod of so large a diameter.

Seventhly, The slide valves, with their various modifications, requiring neither casings nor stuffing-boxes, the patentee claims as perfectly novel; the action of these being seen, admit of mathematical adjustment, and enables the engineer instantly to reverse or stop the engine at pleasure.

Eighthly, For a modification of the crank and beam intended to supersede the use of a beam of the usual weight and dimensions, parallel motion, cross heads, and costly fittings and bearings connected therewith. This mode of converting the reciprocating into the rotative motion, the patentee says, "accomplishes the grand desideratum of making one cylinder produce a more regular and equalized motion than can be accomplished by two cylinders when used to give motion to locomotive engines or paddle wheels."

Ninthly, The condensation by which highly elastic steam of any temperature may be converted into water, without the application of injections, or by the extension of surface by making the cubic contents of the condensing chamber equal to the number of cubic inches of steam discharged.

The said condensing vessel to consist of one or more chambers, which may be made of light copper or other material. The sphere is preferred, as combining strength with great capacity. The conversion of highly elastic steam into the liquid state is to be accomplished exclusively by expansion, without regard to cooling surface. The patentee claims the making the condensing chamber of



flexible substances, as varnished canvas, silk, cotton, or other suitable air and steam-tight material, so as to allow of its alternate inflation and collapsing, every stroke of the engine; and to avoid rupture (should the steam ever arrive at an density exceeding the atmospheric pressure), it must be enclosed in a wove casing, to permit the atmospheric air to enter and escape with great facility, without checking the inflation, or collapsing of the aforesaid condensing chamber. The more this condensing chamber exceeds the proportions given, the more effectual will be its operation, as the steam will expand with less resistance than in a vessel of less capacity, as it more resembles the process of turning highly elastic steam into the atmosphere.

The form of the engine, as applied to locomotive carriages, will be explained by the following figures, and descriptive references accompanying them. *Fig.* 1 on the previous page, is an elevation showing the disposition of the various parts. *Fig.* 2 is a longitudinal section of the boiler and furnace, showing the flues, steam, cylinder, &c. *Fig.* 3 is a transverse section of the boiler, furnace, and calorific regulator, showing its connexion with the blast regulator. *Fig.* 4 is a sectional plan of the lower part of the boiler, furnace, and flues. *Fig.* 5 is a

Fig. 2.

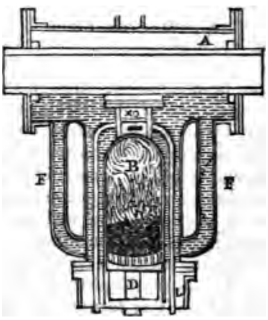


Fig. 3.

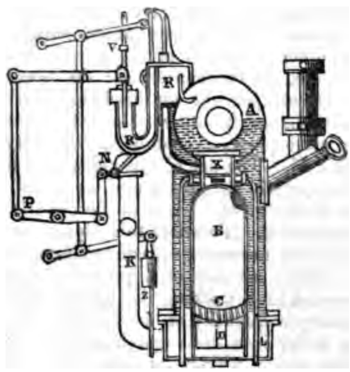


Fig. 5.

Fig. 6.

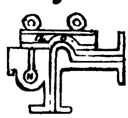
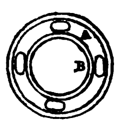


Fig. 4.



longitudinal section of one of the slide valves with its seat. *Fig.* 6 is a plan of the seat, showing the steam and condensing passages. The same letters of reference are used to denote the same parts in all the views. A is the boiler, in the lower part of which, and concentric with it, is placed the furnace B, secured to it by flanges, bolts, and nuts. The grate C is supported upon an iron frame D, and is retained in its place by a wedge, or other simple fastening, and by releasing which, the grate may be withdrawn when required. The furnace is replenished with fuel through an aperture in the crown, by means of a pipe extending outside; the boiler terminates by two slides or doors, which are alternately opened when fuel is admitted; to prevent the discharge of the heated gases, a rake is added, working in a stuffing-box, to force the fuel into the furnace should the pipe get choked. It is the intention of the patentee, however, to adopt a self-acting mode of feeding the furnace with fuel, by means of the

rollers, or other equally efficient means, and which will receive their motion from the steam-engine. E E E E are four flue pipes connected to the top of the furnace, and descending below the bottom of the ash-pit, which prevents the natural flow of atmospheric air to supply the furnace.

The exit of the pipes being carried below the level of the furnace, is adopted in preference to cocks, or such like contrivances, in conjunction with the blast-regulating apparatus. F F are two circulating tubes, by which the annular space round the furnace is more uniformly supplied with water. G, a pipe with its valves, through which the supply of water to the boiler is injected, to replace the quantity evaporated. H the injecting pump for supplying the boiler with water; I, the blowing apparatus, for injecting the requisite quantity of atmospheric air into the furnace. K, a pipe through which the atmospheric air is injected into the casing L, which surrounds the ash-pit, between which a communication is formed by perforations in the lower part of the cylinder which constitutes the furnace; the blast is by this means rendered less partial in its action on the fuel. To one extremity of the pipe K is attached a regulating valve or cover M, which, when closed, prevents the exit of the air contained in the pipe,—the quantity of air discharged through this aperture depends on the area of the opening given to the valve. It is opened or shut, or otherwise adjusted, by means of a screw and handle, or may be operated upon by any other convenient means. This valve is used for regulating the quantity of atmospheric air passed through the furnace, suited to all the variations of resistance. To the other extremity of the pipe K is adapted a hinged valve or cover N, so weighted as to counterpoise the pressure of the air within; the pipe, when closed, compels the air discharged by the blowing apparatus to pass into the casing L, and from thence into the furnace, through the flue-pipes E E, &c., into the atmosphere, excepting that quantity which may be discharged through the valve M. The use of this valve is to limit the temperature of the water, and consequently the pressure of the steam in the boiler, by permitting, when open, the discharge of a great portion of the atmospheric air otherwise required for combustion. To effect this object, the valve N is connected by levers O P Q, with their necessary rods of communication, to the calorific regulating apparatus R, which consists of a piston of sufficient area to overcome the resistance opposed to it, working through a stuffing-box in a cylindrical syphon tube, containing a quantity of mercury as a medium by which the steam, passing from the boiler into the regulating chamber, acts upon the aforesaid piston. S, a safety-valve, with its graduated lever and weight; a loop T is formed on the end of the lever, and embraces the screwed end of the regulator piston; when the nut V comes in contact with the loop, the lever and safety-valve are lifted effectually, preventing the occurrence of accidents, should the safety-valve remain closed beyond the limiting pressure. The action of the safety-valve and lever is rendered simultaneous by two small connecting links. At X is a chamber attached to the crown of the furnace, and connected by a tube Y, with a piston and cylinder of precisely the same description and construction as that used for the calorific regulator R, and may be placed in any convenient situation for operating on a safety slide cock or valve Z, which, when the water in the boiler has evaporated so low as to endanger its safety from a deficiency of supply from the force-pump, is closed, and completely prevents the passage of atmospheric air into the furnace—thus combustion instantly ceases, the ignited fuel being deprived of air. The motion communicated to the piston by the steam generated in the chamber X, operates on the levers shown, until the vertical lever rising with the piston, the detent passes the projecting fin, when the slide Z is instantaneously released, and falls by its own gravity, completely closing the passage through the pipe K. The combustion being suspended, the temperature of the water, and consequently the pressure of the steam, is instantly reduced, thus preventing the destruction of the boiler by the powerful action of the fuel when the heating surface is unprotected by the water. For facilitating the reference, the regulators R are arranged with a view to perspicuity, rather than mechanical exactness. It will be perceived that the safety lide Z with its appendages, have been omitted in Fig. 1, lest it should have

been rendered too confused. The steam cylinder, piston, and stuffing-boxes, being of the usual construction, do not require a particular description, the only peculiarity being the great length of the cylinder compared with its diameter, and the small diameter of the piston rod. The adjustment of the piston in the cylinder is effected by means of screws and nuts at the two extremities, where they are connected to the chains *s s* by the loops *r r*. The slide valves *a a* are connected together by two adjusting side rods *b b*, and have two apertures each, with a connecting chamber *c*. The seats have each three apertures, of equal area with those in the slide, so that the alternate operation of admitting steam to the cylinder, and condensing it, is produced without the aid of a casing or cover over the slide. The movement producing the alternating motion of the slides, is of the tappet kind, capable of the nicest adjustment, by means of screws and nuts at each end of the tappet rods *d d*, which also connect them with the chains. *e* is a carriage for supporting the tappet lever *f*, and the guide rollers *g g*, against which the tappet rods rub, and by which they are prevented from deflecting out of the right line when brought into action. The side rods *b b* are united at *h*, the middle of their length, by a carriage furnished with friction rollers, which is embraced by the forked ends of the tappet rods *f*, and by which the slides are moved. The pressure tending to lift the slides from their seats by the action of the steam in their passages, is counterbalanced by an external pressure produced by two helical springs *k k*, at the back of each slide, and the friction is diminished by two grooved rollers *l l*, working on a guide parallel to the face of the slide. *m* is the condensing chamber, into which the steam is admitted after it has performed its office in the cylinder, where it is permitted to expand freely. The slide valve seats communicate with the upper part by the pipes *n n*, which enter the chamber separately, or united in one pipe. The water produced by the condensation of the steam is drawn from the chamber by the force-pump H through the pipe and valves *o*, which chamber is furnished with an inverted safety-valve *p* to prevent collapsing. The steam is completely excluded from the engine by closing the slide valve *q*. The chains *s s* are fixed to the pulleys *t t*, whose axes turn in bearings on the bracket *v v*, firmly secured to the transverse bearers of the frame work of the carriage. These pulleys should be more in circumference than double the length of the piston's stroke. The reciprocating motion of the pulley *t* and the engine, produce the revolution or rotation of the crank shaft W, by means of a lever keyed on one end of the pulley axis, and the intervention of the connected rod *y*, the crank shaft revolving in bearings attached to the frame of the carriage. The radius of the lever must exceed in a trifling degree that of the crank *w w*. *z*, a toothed spur-wheel working into a pinion of half its diameter on the axis of the carriage-wheels 5, so that the carriage performs a distance equal to twice the circumference of the wheels 5 for each double stroke of the engine. Any other proportions of the wheel and pinion may of course be adopted as the nature of the machine or the required speed of the carriage may render necessary. On the crank shaft W is a pulley 6 grooved, to receive a catgut band for the purpose of driving the machinery to work the blowing apparatus. These wheels 3 and pulley 6, have been represented by dotted lines to prevent confusion. The machinery for working the blowing apparatus consists of two pulleys 7 on an axis 8, supported on two brackets 9 fixed to the side frames of the carriage; one pulley to receive the motion from the crank shaft W, and the other to communicate the motion to the pulley 10. On the axis of the blowing fan a greater number of pulleys may be found convenient to vary the velocity of the blowing fan, according to circumstances. The pulley axis 8 is cranked, to form a winch by which the blowing apparatus can be worked by manual labour, where the engine is at rest, and for which purpose a provision is made to disengage the pulley from the crank shaft W, by sliding the brass bearings in the bracket heads in the direction of the crank shaft. The catgut band will then be slackened, and the pulley will revolve without it; when it is required to be connected with the engine, the reverse of this operation will be necessary, in either of which positions, the axis will be retained by a set screw 11. The force pump is worked by means of an adjusting crank 12, keyed on one end

of the axis of the pulley *t*, and communicating with the pump piston by a connecting rod and slings 13. The pump is secured to a portion of the bracket *v*, projecting below the carriage frame.

To avoid the impediment that is likely to occur occasionally from snow or ice upon railways, Mr. Grime, of Bury, has proposed, under a patent right, dated the 21st February, 1831, to dissolve the same by making the rails hollow, and causing hot water, steam, or hot air, to pass through them, so as to keep them at a temperature above the freezing point. For this purpose a boiler is to be erected by the side of the railroad, at distances of two or three miles from each other. One of these boilers being supplied with water, and heat applied, the water is forced, by the pressure of steam on its surface, through a pipe communicating with the hollow rail, and reaching nearly to the bottom of the boiler, and along the railway, till it ceases to give out a sufficient quantity of heat to melt the snow or ice which may lodge on the rails, when the water is received into another boiler by means of a feeding vessel placed over it. This feeding vessel is connected with the boiler by two pipes,—the one descending from its bottom to very nearly the bottom of the boiler, to form a water communication, and the other from its top to the top of the boiler, to form a steam communication. Each of these communications is provided with a stop-cock and levers, from both of which, as well as one from a cock on the pipe which supplies the feeding vessel, are connected with a float in the boiler, by means of a wire passing through a stuffing-box, in a manner similar to that in Eng. Ency. Vol. I. p. 216, where the float descends by the escape of water through the exit pipe into the rails: the steam and water communication from the feeding vessel to the boiler are thereby opened, while the supply pipe to the feeding vessel is closed, when the water contained therein is forced, by the pressure of steam on its surface, into the boiler, till the float is elevated so as to close the communications between the feeding vessel and the boiler, and to open that between it and the hollow rails, for the admission of a fresh supply of cooled water.

It is stated in the specification, that instead of the hollow rails, hot water pipes may be laid along the line of road, in contact with rails of the usual construction. The lengths of hollow rail are connected together by pieces of copper pipes fitting accurately into the ends of the pieces of hollow rails, which they unite, leaving a space between them sufficient to allow of their expansion by the increased temperature.

On the 2d August, 1831, a patent was granted to Sir James C. Anderson, Bart. of Buttevant Castle, Ireland, for a very judicious arrangement of mechanism for propelling carriages by manual labour. This gentleman designed a carriage, in which as many as twenty-four men were arranged on seats, in the manner of rowers in a boat, but in two tiers, one above the other; the action was nearly the same as the pulling of oars, the only difference being, that by Sir James's plan, all the men sitting on one seat pulled at one horizontal cross bar, each extremity of which was furnished with an anti-friction roller, that ran between guide rails on the opposite sides of the carriage. The ends of each of these horizontal bars were connected to reciprocating rods, that gave motion to a crank shaft, on which were mounted spur gear, that actuated similar gear on the axis of the running wheels of the carriage; so that by sliding the gear on the axis of the latter, any required velocity could be communicated to the carriage, or a sudden stop made. A carriage of this kind it was proposed to employ as a drag, to draw one or more carriages containing passengers after it. The worthy Baronet informed us, that he had chiefly in view the movement of troops by this method, which would enable them to effect their *marches* with greater facility and despatch; hence he justly considered that there might be a great diminution of the peace establishment, without detriment to the service.

Mr. Alexander Gordon, in his *Treatise* before referred to, disapproves of all 'tempts at "homo-locomotion," except the use of his legs, experience having ved, in his opinion, the utter vanity, if not impiety, of all propositions of the d. He instances the *Velocipede* as the most promising of all, yet a failure!

Hence he deduces, that "the inexplicable vital principle bestowed by the omnipotent God upon his creatures cannot be superseded by man's utmost knowledge in mechanical science." In our simple opinion of the matter, Mr. Gordon has entirely overlooked the obvious fact, that whatever mechanical improvement may be effected by the "creature," it must necessarily proceed from the Creator. Admitting, however, for mere argument's sake, that the *Velocipede* was a failure upon the common road, does it not follow that upon a railway, where the resistance to motion is only a fifteenth part of the former, that the effect would be vastly increased by the exertion of the same motive force? And although the railway is one of the results of our increased knowledge, we are far from believing that Messrs. Stephenson and Booth have yet attained the "utmost knowledge in mechanical science" that man is capable of; or that the Omnipotent may not vouchsafe to man such an increase of his capabilities, as will cause the present age to be hereafter regarded as one of comparative darkness.

A patent for a locomotive machine, bearing great similarity to Sir James Anderson's, last described, was taken out by Mr. A. Cochrane, on the 10th of the same month; in conformity with which, a carriage was constructed and impelled through the streets of London soon afterwards; but from some defects in its construction, as well as from there being too few hands to work it, to overcome the weight and friction of the machinery, it did not perform satisfactorily.

About this period several patents were taken out for improvements in the construction of the wheels for railway carriages. Mr. George Stevenson's plan consisted in combining wrought iron and cast iron, in the following manner: The spokes are to be made of wrought-iron tubes, compressed from the circular into an elliptical form; these are to be laid and properly adjusted in the mould, in a true radial position, to receive the nave and the felloes, of cast iron, made by pouring the fluid metal round them. To obtain a perfect junction between the two different kinds of iron, the ends of the tubular spokes are previously glazed by the application of borax over the surface, and then heating the metal until the salt fuses over it. The ring which constitutes the felloes is cast in three portions, with an open space between them, which is done to permit the contraction in cooling, and to allow of their being afterwards keyed up firmly in their places.

Mr. Geo. Forrester, the eminent engineer of Liverpool, also had a patent in September 1831, in which he proposed to unite cast with wrought iron, by a very ingenious and beautiful process, especially with the view of constructing the wheels of railway carriages. The specification informs us, that there is first to be made a skeleton, or light frame of wrought iron or steel, of the form required, but of considerably less thickness. This skeleton is to be brightened by grinding, scouring or filing, so as to adapt it to be tinned. The article to be cast having been moulded in sand or loom, in the common way, the tinned skeleton is carefully laid in the middle of the respective parts of the mould, projecting pieces being attached to the former, to keep it in its proper place: the mould is now to be closed, and the cavities formed by the pattern are to be filled up with fluid cast iron, which completes the operation.

The locomotive steam carriage, contrived by Dr. W. H. Church, of Birmingham, now comes under our observation. His first patent for locomotion is dated the 9th February, 1832; in this the principal novelties claimed are as follows:—First, the frame-work, which is not to be mortised together in the usual way, but united together by L, T, flat, and other shaped iron plates or bars, bolted on each side of the wood work, to obtain strength. This frame-work, well trussed and braced, encloses a space between a hind and fore body of the carriage, and of the same height as the latter, and is to contain the engine, boiler, &c. The boiler consists of a series of vertical tubes, placed side by side, into each of which is introduced a pipe that passes through, and is secured at the bottom of the boiler tube; the interior pipe constitutes the flue; each of them first passes up through a boiler tube, and is then bent syphon-wise, and passed down another till it reaches as low, or lower, than the bottom of the fire-place, whence it passes off into a general flue in communication with an

exhausting apparatus. Some other complications of tubes form a part of the arrangement, which our limits forbid us to describe. Two fans are employed, one to blow in air, and the other to draw it out; they are worked as usual, by straps from the crank shaft. The wheels of the carriage are constructed with the view of rendering them to a certain degree elastic, in two different ways: first, the felloes are made of several successive layers of broad wooden hoops, and these are covered with a thin iron tire, having lateral straps to bind the hoops together; second, these binding-straps are connected by hinge joints, to a kind of flat steel springs, somewhat curved, which form the spokes of the wheels. These spring spokes are intended to obviate the necessity, in a great measure, of the ordinary springs, and the elasticity of the periphery is designed that the yielding of the circle shall prevent the wheel from turning without propelling! Dr. Church, however, proposes, in addition to spring felloes, spring spokes, and the ordinary springs, to employ *air* springs, and for that purpose provides two or more cylinders, made fast to the body of the carriage, in a vertical position, closed at top, and furnished with a piston, with packing similar to the cap-leather packing of the hydraulic press: this piston is kept covered with oil, to preserve it in good order, and a piston-rod connects it with the supporting frame of the carriage. Motion is communicated by two steam cylinders made to oscillate, being suspended on the ends of the eduction and induction pipes over the crank shaft. The crank shaft and driving-wheel axle are connected together by means of chains passing about pitched pulleys; and there are two pairs of these pulleys, of different sizes with respect to each other, by which the power may be varied, by shifting the motion from one pair to the other, by means of clutch boxes.

Several successive patents have been taken by Dr. Church for improvements connected with locomotive carriages; but we regret to state that we have hitherto met with nothing in his arrangements which the eulogies of the press led us to hope for; but, on the contrary, most of the contrivances appear to us to be rather retrogressions than improvements in practical science. The *very* stale and unprofitable idea of propelling upon spheroidal wheels (made so by compression), and thus converting, in effect, a hard level surface into a constant hill, we should never have suspected to emanate from the mature and philosophic mind of the patentee.

It has been stated in the public papers, that Dr. Church's carriage has recently been tried in the streets of Birmingham, and that it performed very steadily; how far the arrangements in that carriage correspond with the description contained in the patents, we are not informed; but we suspect there must have been a radical reform to enable the machine to work at all. A beautiful print of Dr. Church's carriage was published in Birmingham by an artist named Lane, a copy of which is given in the *Mechanics' Magazine*, No. 533.

The next invention we have to record, emanated from the prolific mind of Mr. William Henry James, of Birmingham; it blossomed fairly, but the embryo fruit never came to maturity, owing, we believe, to a deficiency of that metallic nutriment which is indispensable to the successful culture of steam carriages. The specification of his patent (which was dated the 15th of August, 1832,) is too voluminous, and the illustrative drawings too elaborate, to enable us even to condense an intelligible description within the space allowed us. We must, therefore, briefly state that the chief feature is a powerful high pressure boiler, formed of a horizontal tier of cast-iron plates, ingeniously cast with tubular cavities in the body of the metal, and throughout its area. These cavities hold the water to be vaporized, which is constantly made to flow throughout the tier, by an hydraulic apparatus which the inventor denominates a "heart-pump." The fire operates upon the entire bottom surface of each water-plate, and the steam is collected in the highest plate, to which, in addition to the usual appendages, is a steam pipe leading to a trumpet, *which is sounded* by the motion of a lever operating upon a valve at the induc-*'ion orifice.* For the other ingenious arrangement of the carriage, we must *er the reader* to the enrolled documents.

A very singular and interesting proposition has been made by Mr. Richard Badnall, for travelling upon undulating lines of railway in preference to straight or level lines, with the view of saving locomotive power, by the application of the natural force of gravity in the descent, so as to obtain a great momentum in making the succeeding ascent. His plan is best explained by himself in the specification of a patent, dated the 8th of September, 1832, which he obtained for that object.

"If a plummet suspended by a string, as in *Fig.* 1, in the annexed engraving, from the point *z*, be drawn away from the perpendicular line to the point *a*, and there let go, it will fall by its gravity to *b*, in the arc *a b;* but in its

Fig. 1.

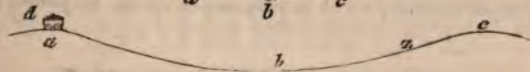


Fig. 2.

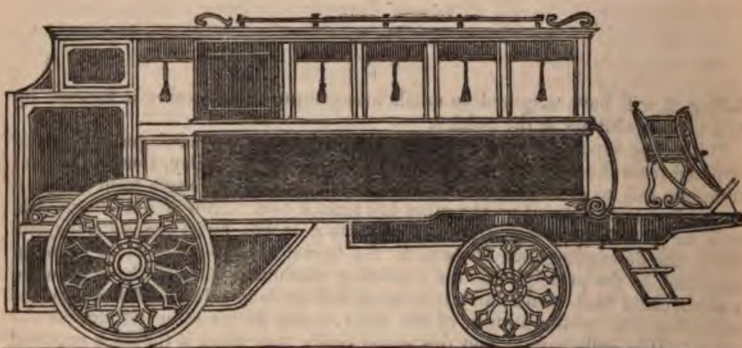
falling, it will have acquired so much momentum, as will carry it forward up to a similar altitude at the point *c*.

"Let it be supposed that a line of rails, or tram-way for carriages, be so constructed from the summit of two hills, as *Fig.* 2, across a valley, that the descent from one hill, as *a*, to the valley *b*, shall subtend a similar angle from the horizontal line to the ascent up the other hill from *b* to *c*. Now if a train-waggon, as *d*, be placed at the summit of the declivity *a*, it will, by its gravity alone, run down the descending line of rails to the lowest point *b;* but, in so running, according to the principles of the oscillating pendulum, it should have acquired a momentum that would carry it forward without any additional force up the ascending line to the summit of the hill *c*, being at the same altitude as the hill *a* It is quite certain that this would really take place if the force acquired by the momentum was not impeded by the friction of the wheels of the carriage upon their axles, and upon the rails on which they run. Hence, subtracting the amount of friction as a retarding force from the momentum which the carriage has acquired in descending from *a* to *b*, it will be perceived, that the force of momentum alone would only impel the carriage part of the way up the ascent *b c*, say as far as *z*. It must now be evident, the carriage *d* would not only pass down the descending line of road from *a* to *b*, by its gravity, but that the momentum acquired in the descent would also impel it up the second hill as far as *z*, unassisted by any locomotive power. In order, therefore, to raise the carriage to the top of the second hill, I have only to employ such an impelling force as would be sufficient to drive it from *z* to *c*, the whole expense of locomotive power for bringing the carriage from *a* to *z* being saved. If now I employ a locomotive power to assist in impelling my carriage from *a* to *b*, I, by that means, obtain a greater momentum than would result from the descent of the carriage by gravity alone; and are enabled by that means to surmount the hill *c*, having travelled the whole distance from *a* to *c*, on the undulating line of road, with the exertion of much less locomotive power than would have been requisite to have impelled the carriage the same distance upon a perfectly *horizontal plane*." Having thus explained the principle of his invention,

Mr. Badnall claims the formation of tram and railroads, with such undulating curves as are adapted to his object. This invention has been the subject of much able controversy in the *Mechanics' Magazine*, and some other public journals, of which our limits render it impossible to give any account. The plausible arguments which were raised in support of the inventor's theory, led to some public trials on the Manchester and Liverpool railway; which, although conclusive as to its inefficacy in the minds of most persons, who doubted before, has apparently had the effect of confirming the patentee in his prepossessions of its utility.

An improvement in the manufacturing of the rails for rail-roads, was patented by Sharman Converse, late of New York, but now of London, on the 29th of September, 1832, a description of which is given in the *Repertory*, for April 1833. The explanation is, however, not very clear; all that we can gather from it being, that the rails are to be connected and sustained longitudinally, by a species of trussing with wrought-iron rods, similar to that employed in trussing girders.

In October, 1832, Mr. Redmund, of the City Road, patented a boiler, especially designed for locomotive uses. It consists of a series of parallel vertical chambers with corrugated sides, for the purpose of extending the heating surface, and accelerating the production of steam in a compact apparatus. The principal difference between it and Mr. Hancock's, is in the circumstance of the corrugation. Mr. Redmund, shortly after the grant of his patent, constructed a very elegant steam carriage, which is represented in the subjoined cut. The

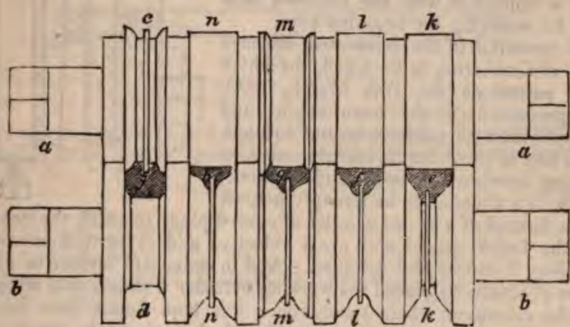


wheels, it will be observed, are of a peculiar kind, and are, we are informed, the subject of a distinct patent; our space will not permit us here to describe them. The arrangement and position of the chief part of the propelling mechanism is the same as Hancock's. The guiding is effected by reins in a similar manner to those of horses, each rein operating separately through the medium of levers in turning the fore wheels of the carriage to the right or left; and to facilitate this motion, each wheel revolves on a distinct axle supported in a frame that turns horizontally upon a pivot, after the manner of Ackerman's patent of 1816.

The great improvement in the construction of iron rails introduced by Mr. Birkinshaw in 1819, and described by us at page 43, have stood the test of experience, and are used now in nearly the same state as he left them. Malleable iron was thus substituted for cast, and at a cheaper rate. Heretofore *the chairs* into which the rails are fitted have been made of cast iron, probably *on the supposition* that there was no other mode of bestowing upon them their *varied form*, and massive parts, at a moderate cost; and the consequences of *this notion* may be witnessed in the thousands of broken chains which may be

found along any of the considerable lines of railroad now being laid down. It is therefore with much satisfaction that we peruse the specification of the patent granted to Mr. Harry Scrivenor, of New Broad-street, dated November 6, 1832; the object of which is to construct the chairs and pedestals of railways of wrought iron, and chiefly by means of the *rolling* process.

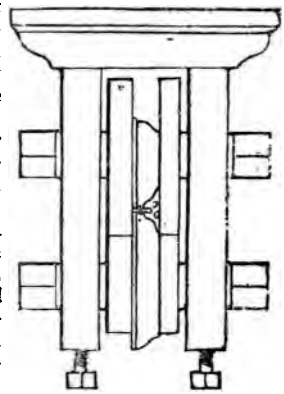
Fig. 1.



In the preceding *Fig.* 1, *a b* represent a pair of cast-iron *rolls* designed for this object, and put in motion by the usual mechanism employed in iron-works. It will be observed that the series of grooves or indentations in their peripheries correspond with the several shapes which the metal is intended to take in its progress through these rollers, until it at length attains the exact shape required to form the chairs or pedestals. Thus, for example, the grooves at *c d* must be adapted to receive an ordinary short thick bar of wrought iron, about two feet long, and six inches square, properly heated for rolling. The bar is first passed through the rollers at *c d*, which causes it to assume the shape shown at *j*. It is then passed in succession through the other grooves on the rollers at *k k*, *l l*, *m m*, *n n*, whereby it successively takes the form shown at *e f g h*. Having thus obtained a long bar of iron of the sectional form shown at *n*, it is next cut into lengths for chairs, which is effected by the mill shears shown at *Fig.* 2, which are worked by the engine. These shears are provided with steel jaws to receive the chair as shown at *v w*, in order that in cutting off the chair it may not be forced out of shape. The opening between the cheeks of

Fig. 2.

Fig. 3.



the chair for the reception of the rail are at present left parallel; the next process is therefore to give these parts a more suitable form for holding down the rail. This is effected by making the chair red hot, and placing inside the recess a mandril of the required shape, with which it is again passed through another pair of rolls shown in the annexed *Fig*. 3; by these the recess is impressed with the required form to adapt it for receiving the intended keys.

The last invention of the celebrated Richard Trevithick, of Camborne, in Cornwall, for which he took a patent on the 19th March, 1833, was for improvements in the steam-engine, and in their application to navigation and locomotion. The first of these improvements consisted in interposing between the boiler and the working cylinder, in a situation to be strongly heated, a long pipe, formed of a compact series of curved pipes, in which the steam, after it has left the boiler, passes with great velocity, and is further expanded in volume before it enters the cylinder. And in order still further to augment this volume of steam, he placed the working cylinder within a case constituting a part of the chimney, where the cylinder was kept hotter than the steam employed in it, and by these means employed the otherwise waste heat in augmenting the power of the engine.

We have now to *notice* the labours of two gentlemen, who are justly celebrated for their ingenuity and skill in mechanical construction, in various departments of art, besides that of locomotion by steam. We allude to Mr. Joseph Gibbs, late of the Kent Road, and Mr. Augustus Applegath, of Crayford in Kent, who had a joint patent, dated 29th March, 1833, for "certain improvements in steam-carriages." To give an intelligible description of the many original contrivances contained in their elaborate specification would, with the requisite illustrations, require five or six of our pages; we must therefore be content with giving an idea of the nature of the subjects, and refer the curious reader (for the present) to the enrolled parchments.

The first described improvement relates to the general arrangement of a steam-carriage. The boiler is of a very novel description, and consists of a series of double cones arranged one over the other, the external angles or spaces between which are receptacles for water, which is circumscribed externally by a cylindrical casing. The fire is in the centre of the series of cones, and operates upon their extensive surfaces; and the flue is so arranged as to repeat the heating operation by a descending current. There is also a curious combination of shafts, wheels, couplers and springs for varying the speed, &c.

The specification of Mr. Jessop's patent, dated the 31st June, 1833, relates to the manner of constructing the chairs in which the rails are fixed; that is, in place of the usual mode of fixing and supporting the chair upon a sleeper, the chair is made distinct from the pedestal, which is attached to the sleeper, and the chair and pedestal are connected by a universal joint or hinge, which permits the pedestal to adapt itself to any irregular sinking of the block or other support on which it rests, and insures a firm and solid bearing upon its base. The patentee also effects it by the combined motion of a hinge joint, or other means permitting motion between the pedestal and chair, and a movable joint formed at the junction of the chair and rail, so as to produce the same effect, and thereby answer the purpose of a universal joint.

The following drawings represent several methods of constructing the universal joint, in all of which *r r* are the rails, *c c* the chairs, *p p* the pedestals, *b b* the blocks or sleepers; *j j* are junction bars of cast or wrought iron, by which the opposite chairs are connected together, and the rails are thereby held parallel to each other, and at a proper distance apart, and are also retained in

a suitable position to insure a flat bearing on the surfaces of the rails for the wheels to travel upon; *s s* are cast-iron bed-plates or sleepers, (which may be used to support the rails where stone is expensive,) so constructed, that the pedestal may be readily adjusted, by the introduction of a wedge or packing, to a proper level, without disturbing the seats which the bed-plates may have acquired on the ground; the same method of construction being applicable to the pedestals, when they are attached to stone blocks.

Fig. 1 is a side view of the railway.

Fig. 1

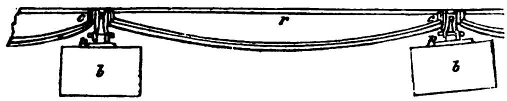


Fig. 2 shows the plan; and *Fig.* 3, the cross section. Two of the stone blocks *b* are drawn in an inclined position to show the action of the pedestal.

Fig. 2.

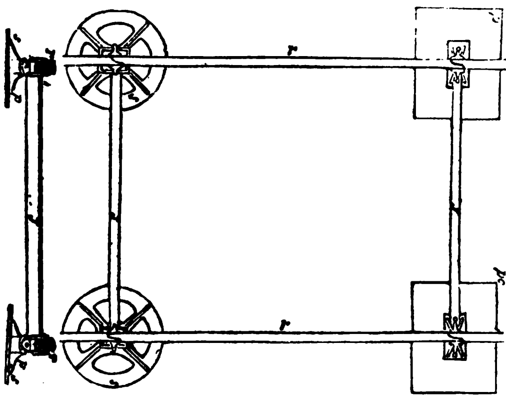
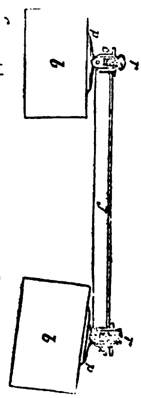


Fig 3.



Figs. 4 and 5, are sections of the pedestal and chair, showing an orbicular universal joint, by means of which the pedestal adapts itself to any irregular sinking of the stone block or other sleeper, whilst the connecting or junction bars retain the rails in their proper gauge, and their opposite surfaces in the same plane or straight line.

Fig. 4.

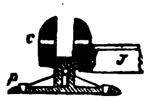
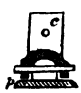


Fig. 5.



Figs. 6, 7 and 8, are other views of the pedestal and chair.

Fig. 8.

Fig. 7.

Fig. 6.

Fig. 9.

Fig. 10.

Fig. 11.

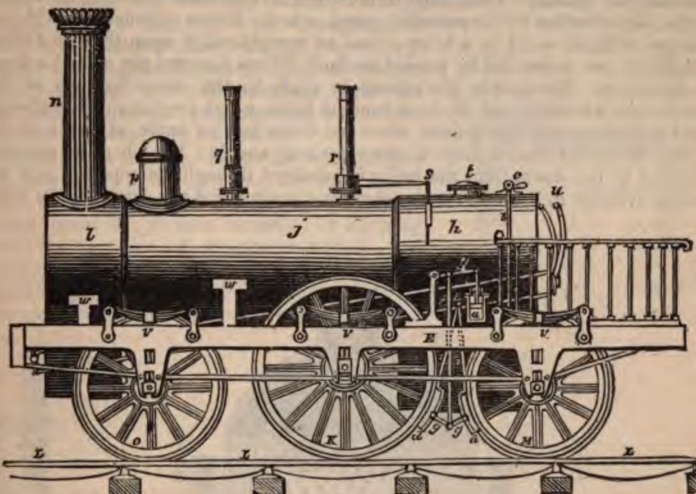
Figs. 9 10 and 11, are a side view, plan, and section of a cast-iron bed-plate, used as a substitute for the stone blocks; showing also the method of adjusting the rails by means of wedges or packings introduced between the bed-plates and the base of the pedestal, which is made to fit in the recess formed in the bed-plate, and secured laterally by means of a wedge or key. The patentee states his claim to consist in "constructing railways, to *the using of chairs and pedestals, which are capable of turning or moving on universal or other similar joints*, as above described, whereby the railway will not be so liable as heretofore to be deranged by the sinking of the blocks or sleepers, whether of stone, wood, iron, or other material."

Until recently the locomotive engines upon the Manchester and Liverpool railway, were usually constructed with a double cranked axis upon the two main wheels of the carriage, which wheels were provided with flanges on their peripheries to keep the engine on the rails. But this mode of construction has been found to be defective, owing to the liability of the crank axis becoming strained or broken, by the excessive friction of the flanges of the wheels against the rails, when the locomotive is entering sidings, turnings, or crossings of the rails, or passing along curvatures in the line. For it will be evident that the carriage has a tendency at these places to run off the rail sideways; which tendency is counteracted by the flanges on the wheels bearing laterally against the inside edges of the rails, on the concave side of the curvature; and, when it is considered that the great weight and momentum of the moving body meets with a sudden inflexible resistance at the extreme end of the lever, or periphery of a large wheel, we may readily conceive its liability to be broken, or at least strained. It is evident that any lateral bending of the cranked axle, although far short of a fracture, will, by putting the wheels out of square, produce a violent surging motion of the whole engine sideways in its further progress along the rails; and such violent action must be very liable to break the cranked axle, or run the engine off the rails. To obviate these disadvantages, Mr. Robert Stevenson (under his patent dated 7th October, 1833), divests the tires of the main impelled wheels of their flanges, and in lieu thereof, employs two small additional wheels with flanges behind the former. These additional wheels are applied beneath the fireplace end of the boiler, for keeping the engine straight on the rails in its progress forwards; and the axles of these wheels being straight, and, consequently, stronger than the cranked, are not liable to be broken or bent, as experience has proved with respect to the axles of the fore wheels, which are precisely the same. In the following cuts are exhibited a side elevation, an end elevation, and an end section of one of Mr. R. Stevenson's improved engines, in all of which figures the same letters of reference indicate correspending parts, though differently viewed. K K are the main impelled wheels on the cranked axle, without any projecting flanges on the tires, which run on the edge rails L. M M are the additional small wheels with flanges, applied beneath the hinder or furnace end of the boiler; and O are the ordinary small wheels with flanges beneath the chimney end of the boiler, where the working steam cylinders are situated. The small wheels, O and M, with flanges, as before observed, keep the engine straight upon the rails; and the large impelled wheels K, have only to advance the engine forwards, and to bear a due proportion of the weight, without having any thing ·· do with keeping the engine on the rails; therefore the cranked axle is rated from all lateral strains, which is wholly transferred to the small wheels 1d M, with flanges, which, having a straight axle, are capable of sustain-t.

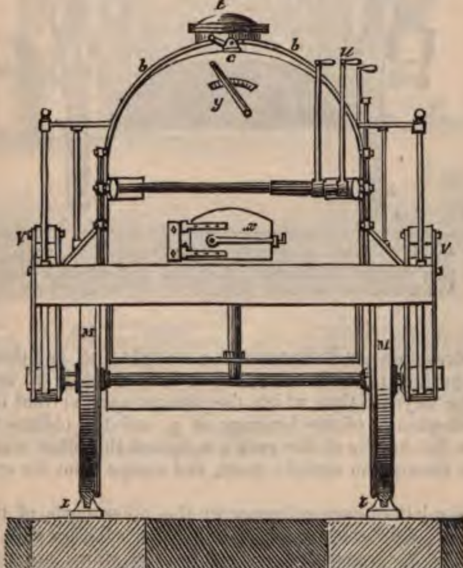
is often of essential importance to be able to arrest the progress of a car- . upon a railway with great promptitude; and the breaks in ordinary use

for this purpose, have not always been found sufficiently potent for that purpose. As a remedy for this inconvenience, Mr. Robert Stevenson, under the

Side Elevation.



End Elevation.



same patent, *proposes* to employ the force of steam acting upon pistons or *plungers in small cylinders*; so that when it is required to stop the train, it is

wheels to the rails, to avoid slipping thereon. The larger the entire capacity of a boiler is, the more metallic heating surface it will contain; and, consequently, render unnecessary that extreme heat which is so prejudicial to the metal. And that diminution of the intensity of the combustion, the patentee considers to be advantageous in another point of view; because the jet of waste steam (which is thrown into the chimney to produce a rapid draught therein, for exciting the combustion of the fuel) may be greatly diminished in its velocity, which will permit the waste steam to escape from the working cylinders with greater freedom than could be permitted with smaller boilers, wherein a greater heat and a more rapid generation of steam, are indispensable to furnish the requisite power.

The following cut exhibits another form of Mr. Stephenson's locomotive engine, such as is now in use, but with the foregoing improvement added thereto. The foremost wheels, at the chimney end of the boiler, are, in this, however, impelled by means of outside cranks and connecting rods, as well as the two middle wheels K, which are on the cranked axle; in other respects, the improvement is the same as in the other engine. The brakes, or clogs, are, of course, applicable to this or any other engine, but they are left out in this instance, as being unnecessary to our illustration.

We have, in the previous parts of this article, alluded to the imperfections, which from time to time manifested themselves in the modes adopted for fastening the rails of edge railways to the chairs and sleepers. Owing to the effects of expansion and contraction, and the violent shocks and strains to which they are subjected, the task of perfecting these parts of the mechanism of railways has hitherto been found one of difficult accomplishment even to the most experienced and skilful. With the view of remedying these defects, Mr. Robt. Stephenson, jun. obtained letters patent in December 1833, in which he says that the object of his improvement is to provide firm and secure bearings at the bottoms of the notches in the chairs for the rails to rest upon, those bearings being capable of self-adjustment, in order that they may adapt themselves correctly to the under parts of the rails; and the making of adequate provisions for fastening the iron rails securely downwards upon such self-adjusting bearings, as well as for confining the rails laterally within the notches in the chairs, but in such manner that the self-adjusting bearings will not be subject to be deranged, nor the fastenings to be loosened, by the effect of any such slight tilting or inclination of the chairs in the direction of the length of the rails, as may result from partial or unequal subsidence of the ground beneath the stone blocks or wood sleepers upon which the chairs are fastened, nor by the effects of any such slight elongations and contractions in the length of the rails as they are usually liable to from ordinary changes of temperature. Mr. Stephenson's mode of effecting this, is by the application of a self-adjusting segmental bearing piece into a suitably-formed concavity, made below the level of the bottom of the notch of each chair; the flat or chord side of the segmental piece being uppermost, and forming the bearing-surface at the bottom of the notch in the chair. Upon that flat bearing-surface the under side of the iron rail is to rest, so that the bearing-surface will always accommodate itself to the under side of the rail, and form an even contact therewith, in consequence of the circular side of the segmental piece adapting itself to the required position, by turning in its concave cell. The specification of this patent describes the action of these parts, and all the subordinate pieces by which the connexions are formed, with great minuteness. It will however be sufficient, for the generality of our readers, to describe the illustrative drawings that accompany the specification. *Fig.* 1 is a perspective view, and *Fig.* 2 a lateral elevation; *Fig.* 3 is a transverse section, and *Fig.* 4 a horizontal plan of a chair, for supporting and uniting the extremities of the lengths of iron rails for edge-railways. A A is the flat bottom or base of the chair, which is to be bedded upon the stone block or *wooden sleeper*, and firmly fastened thereto by spikes driven down through the *holes a a*. *B B* are the cheeks of the notch in the chair, that notch being the *parallel space* which is left between the cheeks, for the reception of the *rails C c D d*, which may join together with a half lap-joint, as is shown in

perspective at *Fig.* 1, and in the plan *Fig.* 4, the overlapping parts *e d* being of the same size, or nearly of the same size, as the other parts of the rails, and

Fig. 1.

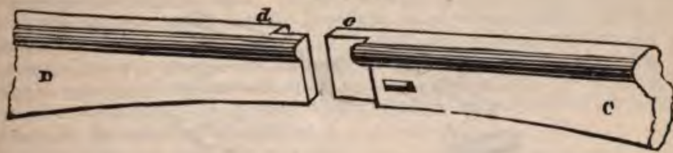


Fig. 2.

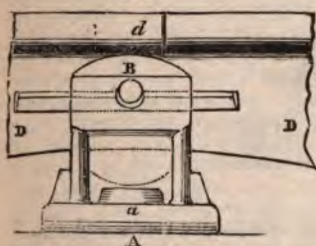


Fig. 3.

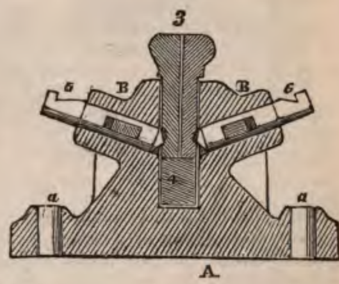


Fig. 4.

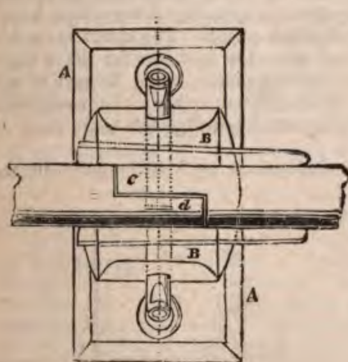
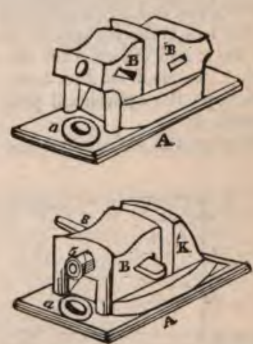


Fig. 5.



those parts are included within the notch of the chair. The bottom of this notch is deeper than is necessary for receiving the rails, and is depressed into a concavity of a suitable form, for receiving the segmental bearing-piece which is shown on the next page, at 4 4 4, in plan, elevation, and perspective: the under edges of the rails rest upon the uppermost flat surface of this bearing-piece. The small figures 5 and 6 are cylindrical pins, which are fitted into cylindrical sockets, through each of the cheeks or sides B B; and 8 and 9 are tapering or wedge-like keys, which are inserted through suitable mortices in the cheeks and across the pins 5 and 6, for the purpose of forcing forward those pins, so that their pointed extremities may press obliquely upon the lower par

of the grooved recesses in the rails, with a bearing-down action, to confine the rails downwards upon the bearing-piece, and laterally in the chair. The cylindrical pins are shown detached, in order to explain the manner in which the pointed extremity applies into the grooved recess in the rails, so as to exert a

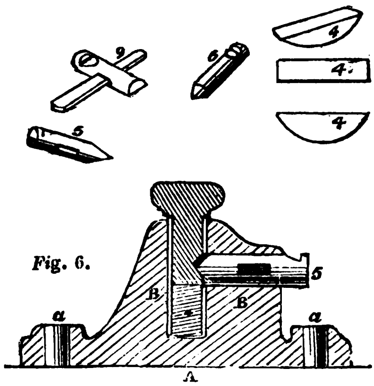
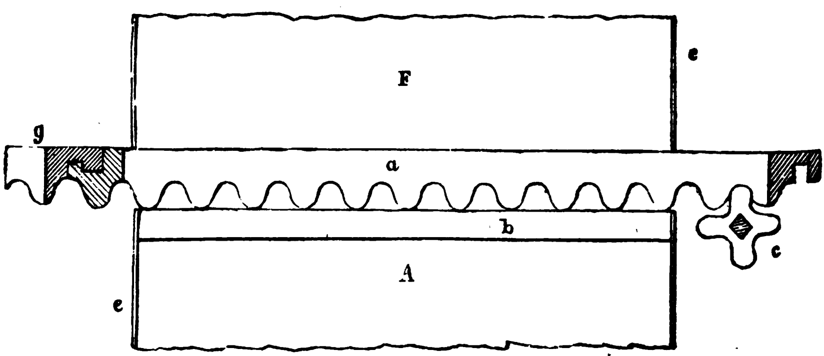


Fig. 6.

bearing-down action thereon. *Fig.* 5 represents perspective views, and *Fig.* 6 a transverse section of a chair for supporting the iron rails at intermediate distances between the extremities or junctions of their several lengths; it has only one cylindrical pin 5, fitted through one of its cheeks B, the opposite cheek K being a flat vertical surface, against which the flat side of the rail is pressed and held firm, by the keying up of the cylindrical pin 5, so as to confine the rail laterally at the same time, that the oblique action of the point of the cylindrical pin 5, in the grooved recess of the rail, may produce a bearing-down action, which confines the rail down upon the segmental bearing-piece. The chairs are made of cast iron; the sockets for the cylindrical pins, the mortices for the wedge-like keys, and the cells for the segmental bearing-pieces, being formed in the casting, as well as the holes for the holding-down spikes; the wedge-like cross keys, the cylindrical pins, and the segmental bearing-pieces, are made of wrought iron.

At page 128 we alluded to an improvement made by Mr. Hancock, in the



aces of boilers, which was patented by him on the 15th January, 1833; *object of which is to* remedy the inconvenience experienced by the forma-

tion and adhesion of clinkers upon the fire-bars, by which the combustion of the fuel is checked, and, consequently, the production of the steam, as well as the velocity of the carriage, considerably lessened. By the present contrivance, Mr. Hancock draws out the foul floor of bars, and replaces them by a clean set, which operation, he states, is performed in much less time than is required to imperfectly clear by the rake. In the figure on the preceding page, F represents the space occupied for the fire-place, in a vertical plane, and A is the ash-pit. *a* is a floor of bars, in one casting, and in their position for use; the outer bars on each side are cast with teeth underneath, forming racks; and there is a fixed rail under each rack, one of which is seen at *b*: these support the racks, and, consequently, the whole floor of bars, which are removed by turning the spindle of the pinnion *c*, of which there are two, one at each end of the spindle, so as to operate upon both sides of the grating at once. When a floor of bars has become foul, a clean floor is attached to it, as partly shown by the hooked joint at *g*, by which, as the foul floor is drawn out, the clean one is drawn in.

A patent for improvements in boilers for locomotive engines was obtained by Mr. James Frazer, on the 7th May, 1833, upon the basis of which it is said he constructed a steam carriage, but of the completion or performance of which we are at present uninformed. Annexed is a transverse section of the boiler; the fire-place is at *a*, and the smoke, &c. is conveyed through an eccentrically-curved tube *b b*, imparting its heat to the surrounding water, in its progress to the chimney. There are cross pipes, which pass quite through the flue-tube at various places, as shown by the dotted lines, that the circulation of the water or passage of the steam may not be impeded. The patentee has included in his patent some other modifications of his plans, wherein a great number of small flue-tubes are used to distribute the heat throughout the water, and to serve as supports to the fire-place and flues.

A very ingenious proposition for making use of the power of a horse, moving at his slow working pace, to communicate a high velocity to carriages upon a railway, through the medium of a new arrangement of pulleys and ropes, was invented by Mr. Joseph Saxton, of London, for which he obtained a patent, on the 20th June, 1833. The invention consists in the application of pulleys of different diameters, termed "differential pulleys;" the principle of the action of which will be comprehended by the following illustration:—

Fig. 1 (in the following page) represents a combination of two pulleys, their diameters being as 6 to 7; *a* being the larger pulley, and *b* the smaller one; *c d* is an endless rope, passing over the sheaves *e e*; the part *c* of the endless rope first takes a turn round the larger pulley *a*, and the part *d* also takes a turn round the smaller pulley *b*. If then the rope *d* be moved in the direction of the upper arrow, it will draw the lower part of the pulley *b* in the same direction; meanwhile, the part *c* of the endless rope will be moving in the direction of the lower arrow, and will move the lower part of the pulley *a* in the same direction with this part of the rope; consequently, the two pulleys *a b* (which are fixed together) would turn on the mean point *f*, as a fulcrum; *g* is the centre of the two pulleys. Let it then be supposed, that the part *d* of the endless rope be moved from *h* to *i*, it will be evident that the centre

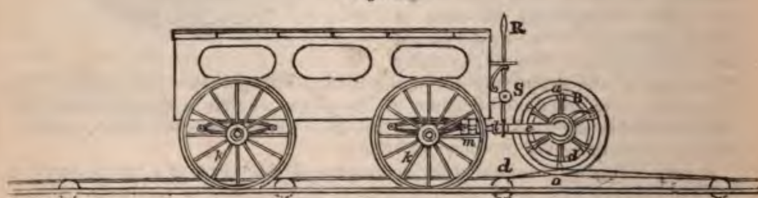
g of the differential pulleys *a b* would be moved to the point *j*, and, consequently, if any object were connected to the centre *g* of those differential

Fig. 1.

pulleys, it would be propelled from *g* to *j*, by the endless rope *c d* being moved the much smaller distance of *h* to *i*, indicated by the dotted lines; and these distances will be as 13 to 1.

Fig. 2 represents the contrivance applied to an ordinary carriage, having four wheels, as usual, two of which, *k k*, are shown. *a* and *b* are the differential pulleys, placed on an axis *g* (see *Fig.* 3); *m* is a frame which carries the differential pulleys, and turns in bearings *n n*, affixed to the carriage. The pro-

Fig. 2.



jecting arm *m* is forked at the outer end, as shown in *Figs.* 2 and 3, at *o o*; and the forked ends serve as bearings to the axle *g* of the differential pulleys, the pulley *a* being permanently fixed to the axle *g*, whilst the pulley *b* is capable of turning loosely on this axis, when it is not retained by the pin *q*, which locks the two pulleys *a* and *b* together at the times required. By disconnecting these pulleys, the power will no longer tend to drive the carriage. R (*Fig.* 2) is a lever, turning on a fulcrum S: the upper end of this lever is formed into a handle, and placed under the control of a person sitting in front of the carriage; the other end of this lever receives the flanch of a sliding socket *l* within it, as shown in *Fig.* 2; *u* is a bent lever, having its fulcrum at *v*, on the ed frame *o*, as shown in *Fig.* 3. One end of this ed lever *u* has a crotch, which receives the flanch l of iding socket; and the other end of the lever *u* has crotch to slide the socket *w*, on the axis *g*, backwards and forwards,

Fig. 3.

x is an arm, fixed to the sliding-socket *w*, and carrying the pin *q*, by which the wheels *b* are fastened together: a spiral spring is placed on the pin *q*, to force it in, when a part of the pulley which is cut away, comes opposite to the bolt; there is also a spring to prevent a sudden concussion. In *Fig.* 2, *c d* is an endless rope, the part *c* taking a turn round the pulley *a*, and the part *d* taking a turn round the pulley *b*, as described in *Fig.* 1. This endless rope is supported, at proper intervals of the road, on sheaves, and passes round a rigger at each end, to which is attached an apparatus for preserving it sufficiently tight. Now suppose the pin *q* to be passed through the two pulleys *a b*, to retain them together, and the endless rope *d* be moved in the direction of the arrow, a similar action will take place to that described in *Fig.* 1; that is, the carriage (being attached to the centre *g* of the differential pulleys *a* and *b*) will be propelled forward on a railway with a much greater velocity than the rope travels; and the distance so travelled by the carriage, in comparison through which the rope moves, will depend on the differences of the diameters of the pulleys *a b*; and the nearer the respective diameters of the pulleys approach each other, the greater will be the relative velocity the carriage will travel, to the velocity with which the rope moves. In order to prevent the two parts of the rope rubbing against each other, in leading on, and of the differential pulleys, the axis *g* of these pulleys is placed at an angle a little varying from a right angle, with the direction of the motion of the carriage.

Fig. 4.

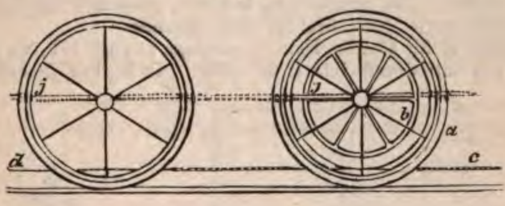
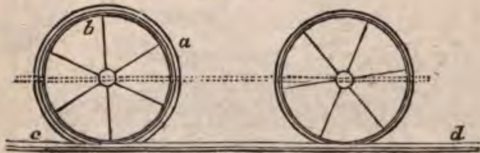


Fig. 5.

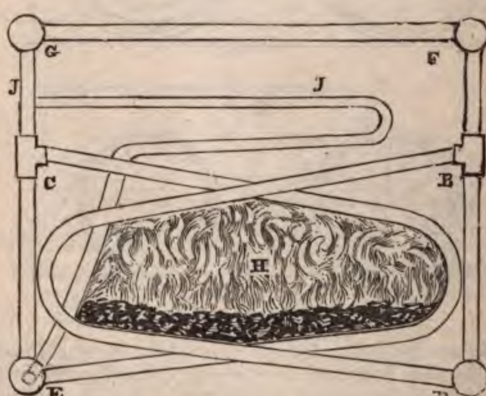


Figs. 4 and 5 show two different applications of the invention from that shown in *Fig.* 2; for in these instances there is only one pulley, whilst the two front or two back wheels of the carriage act the part of the other pulley. In *Fig.* 4, *a* is one of the front wheels of the carriage, which also acts as the larger pulley; *b* is the smaller pulley, and is the only one around which the rope *c d* passes; the wheels *a*, and the pulley *b*, being on the same axis *g*, which runs from side to side of the carriage, and turns in bearings affixed to the carriage. In this arrangement the point *f*, at which the wheels touch the rail, becomes the fulcrum on which the w eel *a* turns; and it will thus be evident that if the rope *c d* be drawn forward in the direction of the arrow, a similar effect will be produced as described in *Fig.* 2, and as shown in dotted lines in *Fig.* 4. Nevertheless, if the wheels and pulleys *a* and *b* be of the same relative diameters as those in *Fig.* 2, the carriage at *Fig.* 4 would only be propelled at the velocity of seven to one, owing to the fulcrum, at which the wheels *a* turn, being removed

from the mean point *f*, *Fig.* 2, between the two diameters, and placed at the extreme end of a radiating line, drawn from the centre of the wheel *a* to the point at which it touches the railway. In *Fig.* 5 the rope is passed around the pulley *a*, which is the larger, whilst the carriage-wheels act the part of the smaller pulley *b*, the pulley *a* and the wheels *b* being on the same axis *g*. In order that the pulleys in this arrangement may stand at an angle for clearing the rope, the axle *g* is formed of three parts, connected by universal joints; and one of the wheels *b* thus travels a little forwarder than the other, and thus the rope will clear itself. And, it should be observed, that in both these arrangements, the pulley around which the rope passes is to be made capable of being disconnected from revolving with the axle as described in *Figs.* 2 and 3. In the arrangement, *Fig.* 5, the fulcrum *f*, on which the wheels turn, is the point at which the wheel *b* touches the rail or road; and the difference in the arrangements, *Figs.* 4 and 5, is, that the power in *Fig.* 4 is applied by the rope between the fulcrum *f*, and the centre *g*, of the wheels or pulley *a b*, where the weight to be drawn is attached; whilst, in *Fig.* 5, the fulcrum is between the centre of the pulley and wheels *a*; consequently, the arrangements differ in the order of leverage, and, in this instance, will be as six to one. In these two last arrangements, the rope *c d* may be either an endless rope, as described in *Figs.* 1 and 2, or the rope may be single, and, taking a turn around the pulley *a* or *b*, is to be wound on a drum at each end of the distance, which is to be run by one length of a rope.

This invention has been recently tried on a piece of railway near the Regent's Park, and, we are informed, did not fulfil the anticipations of the ingenious patentee. The proposition, however, possesses merit, and may be very beneficially carried into effect for short distances.

In our notice of Sir Charles Dance's carriage at page 173, we alluded to a boiler that was introduced into it in 1833. It is thus described by Mr. Gordon:—

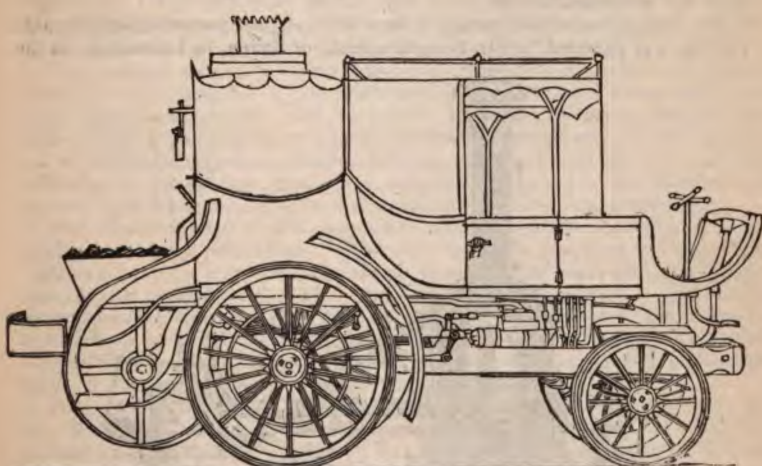


"In 1833 a patent was obtained by Sir Charles Dance and Mr. Field, for an arrangement of tubes, which was considered superior to Gurney's. The bent pipes of Gurney's boiler will be discovered upon reference to the figure, and the whole will be found to consist of two of Gurney's boilers, but without the separators backed into each other. The coil-pipe J is here used, conveying the cold, or rather the cooler, water from the tank to E, from whence it rises to C, becoming heated in its passage upwards. Water pumped into D also ascends to B in the same manner; and at B and C the steam from the two distinct

boilers E C and D B, rises up to F and G, and is drawn off to the engines, whilst the cooler particles descend in the vertical pipes below C and B, to pass again over the fire with other water, going in the upward direction.

A tubular boiler for locomotive purposes, of considerable efficiency in the production of steam, was patented jointly by Mr. John Squire and Colonel Maceroni, on the 18th July, 1833. It consists of nine rows of upright cylindrical tubes, each row containing nine tubes, so that there are eighty-one in all. In the middle of these the fire-place is situated; and to obtain the requisite space for it and the fuel under combustion, a portion of the interior ranges of tubes are proportionably shortened, as well as three of the front tubes, to form a fire-door. All the vertical tubes are connected by means of small horizontal tubes at the top and at the bottom; the upper being a steam communication, and the lower a water communication; but as they are all open to each other, and the application of the heat cannot be precisely uniform in every part, a circulation of the fluid necessarily ensues. To avoid clinkers, and prevent the destruction of the fire-bars, the latter are formed of hollow tubes, filled with water, and communicating with the vertical tubes. The steam is conducted from the latter tubes, by means of small pipes entering the otherwise close tops of each, into a central recipient, from which the engine is supplied. The flame and heated matters being diffused round and throughout the whole series of tubes, of course produce a rapid generation of steam.

Having thus obtained the heart and vital fluid for locomotion, Messrs. Squire and Maceroni set about combining the sinews, bones, and joints, which comprise the entire machine; of which the following cut will afford a tolerably correct idea.



This carriage, Mr. Gordon says, "is a fine specimen of indomitable perseverance," and that it is not uncommon to travel from 18 to 20 miles per hour by it. The engines are placed horizontally underneath the carriage body; the boiler is at the back, and a winnowing blast is employed to excite the combustion of the fuel, the supply of which is regulated by an engine man, who has a seat at the back for attending to it. The passengers are placed in the open carriage body, and their seats are formed upon the tops of the water tanks. There are two working cylinders $7\frac{1}{2}$ inches diameter, and $15\frac{3}{4}$ inches length of stroke. *The steam-ways are* $2\frac{1}{4}$ and $2\frac{3}{4}$ inches diameter. We regret that our *space will not permit* us to extend our notice of the operations of the high

8th of October, 1834. The preceding figure affords a side elevation of the machine, with such portion as could not be readily explained otherwise in section; *a* is the ash-pit, *b* the fire-place, opening above into a dome *c*, of the boiler *d d*, and surrounded by water; the external figure of the boiler is that of a vertical cylinder; and as the dome *c* occupies the centre, the water chamber is for the most part of an annular form; this annulus has passing through it, vertically, numerous tubes open at each end, for the smoke and heated gases to pass from the furnace throughout the body of water, into the flue *e* above, and thence into the chimney *g*. The draft through the furnace is increased, by introducing the induction steam pipe *k*, from the engine into the throat of the chimney, where a jet of steam is thrown upwards, in the way now commonly practised. *f* is the steam chamber, enveloped in the heated gases that ascend from the furnace, which are made to impinge upon it with greater force, by the introduction of a plate of iron shaped like an inverted funnel; *i* is the steam pipe, which conveys the steam from the chamber *f*, into the valve boxes *k*, worked by a series of levers at *l*, that are put in motion by bevel gear, and a crank motion partly introduced. It is now to be clearly understood, that there are three steam cylinders *m*, but as they are all in a row, only one can be seen in our view; each of these cylinders is provided with suitable valves, and working gear, to admit the steam *on the top only* of each of the pistons, at the time of the descent of each, and to allow of its escape on their ascent. The bottom of each of the cylinders is open, and the piston rods *n*, are jointed to the bottoms of the pistons, the latter being steadied in their motions by small lateral rods passing through guide holes. The three piston rods act directly upon a three-throw-crank, the equi-distant positions of which in the circle cause the pistons to continue their reciprocating action, and the crank its rotative motion, with uniformity. Fast and slow motions, and clutch boxes for varying the speed, are provided in the usual way. In our diagram is shown a pinion *o*, on the crank axis, driving a wheel on the axis of the running wheels.

The patentee especially claims under his patent, the combination of two or more cylinders, each having its lower end open, so that the steam shall press only upon the upper surfaces of the pistons, and communicate its power to the crank shaft, or running wheels, in a downward direction only: which he considers will cause a greater adhesion between the wheels and the rail, and less vibration to the carriage, than when the power is applied to the wheels in an upward and downward, or a forward and backward direction, alternately.

The wheels applied to this locomotive also possess some novelty, and are claimed under the patent right. They may be briefly described to consist of a cast-iron nave, duly formed and turned, to receive the edges of discs of plate-iron, in lieu of spokes; the felloes or external rings being fixed to the discs by first expanding their circumference by heat, and allowing them afterwards to contract, so as to receive the edges of the discs in grooves turned to receive them. The several parts are afterwards secured by bolts, screws, rivets, and keys, in a manner too well understood to need description.

Some improvements of considerable originality have been proposed by Mr. Robert Whitesides, a wine merchant, of Air, in Scotland, for which he obtained a patent, dated the 20th of November, 1834. The object of his first improvement is, to obtain a firm connexion between the moving and the moved parts, or between the steam engine, and the axle of the wheels which move the carriage. In order to perform this effectually, the springs usually placed over those wheels are placed in them; and to prevent the twisting force of the machinery from tearing them out, two quadrangular framings are attached to the wheels, which will be explained with reference to the cut on the following page.

a, b, c, d, is the outer circumference of the wheel, formed of iron: the spokes are rivetted, or otherwise fastened, to the tire at one end, and at the other, either rivetted to a flat ring, or screwed to one which is thickened in parts to receive the screw. The central space of this ring varies according to the play intended to be allowed to the springs; in the present instance, it is eight inches diameter. The points, *a, b, c, d*, are equi-distant from each other. Between *a* and *c*, and *b* and *d*, are placed two rods, which must be firmly attached

to the rim of the wheel at both ends, and parallel to each other. On these rods traverses a quadrangular iron framing, *e, f, g, h*, by means of rings which embrace the rods. On this framing, *e, f, g, h*, slides another frame, of the same nature, in a direction at right angles to that of the first, but instead of the rings, as in the first, being attached to rods, and the cross-bars *i* and *j*, they are affixed to a plate of iron, in the centre of which is a hole, to allow of an axle-box passing through. The box is bolted to the aforesaid plate (by means of a flanch, cast along with it), and passes through the

hole or opening in the centre of the wheel, so that one end of the springs may be fastened to it, and the other end to the circumference of the wheel. The whole wheel may then be covered over on each side, with a thin iron plate, to preserve the frames, &c., from the wet and dust, taking care, at the same time, to allow in the inside plate, a hole of sufficient size (say eight inches diameter), for the axle to play: this hole may be covered over with a piece of water-proof cloth, connected water-tight, on one part to the axle, and on the other to the inside covering-plate. The patentee observes, that springs have been before placed in, or adapted to, wheels; but he confines his claim to the application of the two quadrangular frames, as above described, for preventing the strain of the power applied to propel the same coming on to the springs. Another improvement included under this patent, relates to a method of reducing the friction of rotary engines, by placing the lubricating fluid in one or more reservoirs, under a pressure a little superior to the force of the steam, which presses upon the piston, for the purpose of forcing it into every crevice, and between all the moving parts of the engine, where there is a liability of leakage of steam, so as to prevent both the loss of steam when these parts wear, and the reduction of friction to its minimum. The arrangements for this purpose we have not space to describe.

For preventing or lessening the concussions to railway carriages upon stopping or starting, a contrivance, called the "buffing apparatus," has been resorted to on the Liverpool and Manchester, and other railways. This apparatus consists of a series of rods and levers, acting on springs similar to the elliptical carriage springs; the contrivance is complex and expensive, and it is found to communicate to the carriages of a train a swinging lateral motion, which causes much friction, and renders the vehicles liable to be thrown off the rails. To obviate these disadvantages, Mr. T. F. Bergin, of Dublin, took out a patent for an invention on the 4th March, 1835, which consists of a combination of coiled

springs, with rods proceeding from end to end of the carriage, designed not only to prevent the concussions at stopping or starting, but likewise any prejudicial effects taking place, in the event of two trains coming into contact; also to receive and transmit the motion of one carriage to another free from that abruptness which is alike unpleasant to the passengers and detrimental to the vehicles.

The following *Fig.* 1 represents a side elevation of one of the Dublin and Kingstown railway carriages, with Mr. Bergin's invention applied to the same. *Fig.* 2 is a plan of the under part of the same, the body being removed. *a a* represents a slight frame, made of two similar plates of iron, screwed to each

Fig. 1.

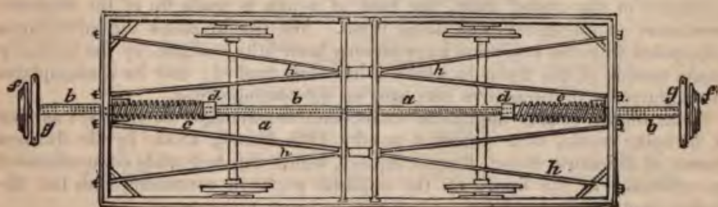


Fig. 2.

other about three inches apart, and resting upon turned bearings in the centres of the axles. A wrought-iron tube *b b*, about three inches in diameter, the entire length of the carriage, and extending about two feet beyond each end, is supported on this frame by rollers, which allows the tube to be moved thereon lengthways with facility. On this tube is placed, at either end, within the frame of the carriage, about four feet of helical springs *c c*, of graduated strengths; one end of each of these sets of springs abuts against a strong collar *d*, fixed to the tube *b*, and the other end against a small box of iron attached to the frame, and furnished with one of the bearing rollers before-mentioned, also with two friction-rollers resting against the inner side of the carriage-frame end. To each extremity of the tube *b b* is attached a buffer-head *f f*, by means of a rod of iron passing through the tube, and connected to the buffer-heads by screwed nuts sunken below their surfaces. At the back of each buffer-head is a cross-bar *g*, to which, by chains and hooks, the carriages are attached together. This apparatus lies loosely on the axles, and is perfectly independent of the frame-work of the carriage, which is sustained by springs in the usual manner; and there are long vertical slots made in the framing, through which the buffing-tube passes, which permits the frame to rise or fall, according to the pressure of the load thereon, without affecting the height of the buffing apparatus above the road.

The action is as follows:—The train being moved in the direction of the arrows, the locomotive power is applied to the cross-bar *g*, and draws forward the central tube *b*, thereby compressing the springs *c c* between the collar *d* and the friction roller-box *f*, which rests against the end of the carriage frame, without moving the latter until the elastic force of the compressed springs becomes sufficient to overcome the resistance presented by the friction of the carriage and load. The carriage then begins to move forward so slowly, as almost to be imperceptible to persons seated within; the second and each succeeding carriage in the train is by similar means brought from a state of rest into motion. In case of one carriage running against another, the resistance is offered by the furthest end; the effect being to drive the tube *b* forward, compressing the springs at the opposite end from which the concussion is given and the carriage will be but little affected by the blow, until the elasticity communicated to the springs, by compression, overpowers the resistance of the carriage, which then begins to move, actuated by a force just sufficient to start it. The coiled springs, which, as before stated, are four feet in length, have a range of action of about two feet, beginning to be compressed by a force equal to about twenty pounds, and presenting a total resistance to entire compression of upwards of two tons. A spring of this strength, the patentee states, has been found suitable for carriages weighing, when loaded, about four tons. It will be observed, that the entire resistance to the action of the springs is on the ends of the carriage frame; the middle of each is armed with a strong plate of iron, about fifteen inches square, through which pass the tension rods *h h*, *Fig.* 2, to the outer angles of the opposite ends of the frame; consequently, these rods receive the entire force of the springs. The springs at either end of each carriage act totally independent of those at the other end, and of all the carriages in the train, except that to which they are attached; each has therefore to bear only its own share of the resistance of the entire train, the sum of which is made up of the separate resistances of all the springs acted upon. Mr. Bergin states the advantages anticipated from his invention have already been fully realized, by the perfectly steady motion of the trains to which it has been applied; and he contemplates its employment to locomotive carriages on the common road.

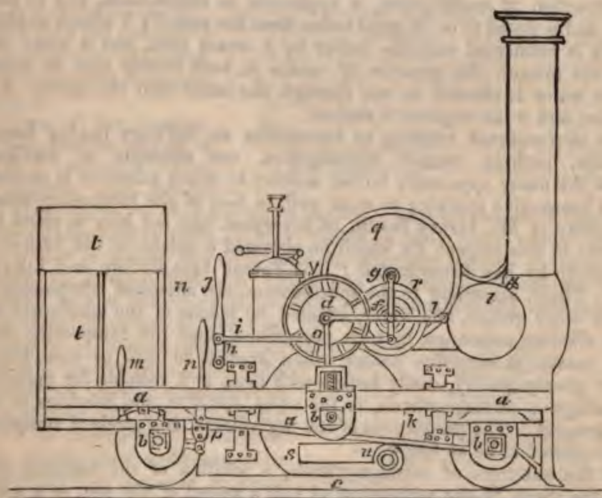
Some improvements applicable to locomotive carriages for railways as well as turnpike roads, were patented on the 17th March, 1835, by Mr. Butters Bacon, of Sidmouth Street, Regent Square, which will be readily comprehended by reference to the figure on the opposite page, in connexion with the following description.

The frame of the machine, as shown at *a a*, is of the usual form; but it extends to the rear sufficiently for a convenient fuel room and engineer's stand. The wheels are of common structure, being made of cast or wrought-iron, with arms, flanged rims, and fixed naves; they are attached to their axles respectively, and these, made of iron, project through the naves and run in boxes, as seen at *b*; these boxes being capable of exact adjustment, so as to level the engine. The driving wheel is attached to the frame, and works in boxes; but its rolling friction on the railway is regulated by a spiral spring and lever, and the pressure of the roller *d*, as hereinafter described. This driving wheel, as introduced by a line at *c*, is moved by the rolling friction produced by applying the roller *d* to its periphery, as seen at *e*, the larger periphery of the rollers *d* being in contact with one of the smaller concentric rollers, as seen at *f*; this set of rollers being put in motion by the pinion at *g*, which takes into the teeth cut in the periphery of the wheel *h*, attached firmly to the set of rollers, and revolving with them upon the same axis, so that when the pinion at *g* turns under its axis towards the smoke-pipe, the wheel *h* and the set of rollers turn over their axis in the same direction, whereby the roller *d* turns under its axis in the same direction, and the driving wheels over their axis forward, the driving wheels being firmly fixed to the same axis.

It will be perceived that the roller *d* is sustained in its position bearing upon the top of the driving wheel by a perpendicular standard, which descends to the boxes of the driving wheels, and is so connected with the axle of the driving wheels by means of bearing on its axle, or by means of two pair of

screws attached to the frame, and bearing on its axle by plates connecting each pair of screws together, the screws taking into boxes fixed upon the frame in any convenient mode; and these plates being pressed down by the screws upon the roller axis, as that the friction surface of the roller *d* shall always be kept closely in contact with the friction periphery surface, or the periphery of the flange of the driving wheels, and thereby force this to turn on the railroad, it being seen that the driven roller *k* on the same axis with the roller *d*, is forced to turn by the driving concentric roller before mentioned, of which there are three in the same axis, as the toothed wheel *h*, that takes into the pinion *g*.

This pinion is supposed in the specification to be turned by the revolution of a rotary engine, contained within a cast-iron case *p*; but it does not appear that



Mr. Bacon has sufficiently considered this part of his apparatus, as we cannot perceive any abutment for the steam, that would enable it to give any motion at all. The steam, after passing out of the engine, is to pass through the cylindrical tank *x*, to heat the supply water, before entering the chimney. The axis of the set of pressure rollers is suspended by the vertical arm above, and the lower end of the latter is connected to one extremity of the lever *i*, whose other end is connected to an upright lever *j*, whose fulcrum is at *k*, so that when the engineer, who is stationed in the rear of it, draws it towards him, the set of rollers is pressed forcibly against the roller on the same axis, as the roller *d*, which axis is held in its position by the horizontal bar *l*, and the perpendicular standard. This standard is so constructed, that by means of any mechanical force, the roller *d* is made to bear with increased force upon the driving wheels. This standard may permit the axis of the roller *d*, and the axis of the driving wheels, to approximate mathematically and mechanically, as may be needful to give effect to such increased force or closer contact. The pressure upon the driving wheels may be thus varied. Let the after bearing wheels be raised by moving the arm *m*, which is a bent lever, towards the front of the engine, until the weight of it is chiefly sustained upon the forward bearing wheels, and the driving wheels being placed sufficiently in rear of the centre of gravity to sustain the weight in all ascending planes, when it is essential that the weight should be thrown upon the driving wheels. When turning a bend in the road, the bearing wheels are made to turn by means of the arm or lever *n*, and the bars *b*, the longer one of these bearing upon the extremity of the forward axle shoulder,

and the shorter connecting the end of this compound lever as seen at *p*, so that when the lever, or arm *n*, is drawn towards the front by the engineer, the longer bar is moved forward, and the shorter back, and thereby the wheels are turned conformably to the bend of the road: if the bend is to the left hand of the locomotive course, and, by a contrary movement of the lever, if the bend is to the right, they are turned conformably to the bend. At *r* is the bellows-wheel, which is turned by a band from one of the set of rollers; by this means the air is forced into the furnace at *s*.

The construction of the smoke pipe is so contrived, that there shall be within, at the bottom thereof, a recess where there is no current, but into which the cinders are thrown by force of the current, there, ceasing to be impelled by this force, they settle by their own gravity, while the smoke which has not been impelled, ascends by the continued force of the draft. This improvement in the construction of smoke pipes, is applicable to steam-boats, and to standing engines, and is stated to be of great value, from the security it affords against fire. The tank is connected with the boiler by a steam tube, and a water tube, so that by the former, the pressure of steam in both vessels may be equalized, while the water is allowed to run through the latter into the boiler. *t* is the fuel house, and *u* the engineer's station.

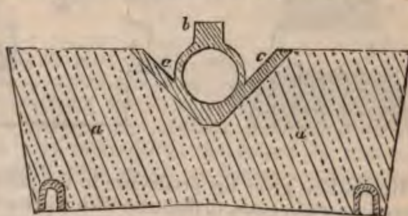
Every circumstance relating to locomotion on railways having become of importance, nothing escapes investigation, nor attempts at amelioration. Amongst the many apparently trivial matters to which attention is necessary to enable a locomotive machine to work well, is that of the lubricating substance. The sagacity of Mr. Henry Booth, of Liverpool, has led him to effect an improvement in this respect, for which he obtained a patent on the 14th of April, 1835; which he has denominated "The Patent Axle Grease, and Lubricating Fluid." These, according to the specification, are chemical compounds of oil, tallow, or other grease, and water, effected by means of the admixture of soda or other alkaline substance, in such proportions, that the compounds shall not be of a caustic or corrosive nature, when applied to iron or steel, but of an unctuous greasy quality, easily fusible with heat, and suitable for greasing the axle-bearings of carriage wheels, or the axles, spindles, and bearings of machinery in general. The proportions of the ingredients, and mode of compounding them, are stated to be as follow:—

"For the axletrees of carriage wheels, a solution of the common washing soda of the shops, in the proportion of half a pound of the salt, to a gallon of pure water; to one gallon of this solution, add three pounds of good clean tallow, and six pounds of palm oil. Or instead of the mixture of palm oil and tallow, add ten pounds of palm oil, or eight pounds of firm tallow. The tallow and palm oil, or either of them, and the solution as described, must be heated together, in some convenient vessel, to about 200° or 210° of Fahr. and then the whole mass must be well stirred or mixed together, and continually agitated, until the composition be cooled down to 60° or 70° of Fahr. and have obtained the consistency of butter, in which state it is ready for use.

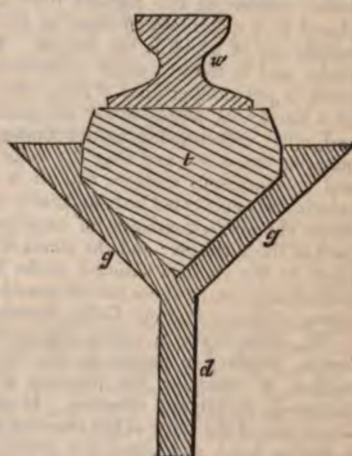
The patent lubricating fluid, for rubbing the parts of machinery in general, is thus made: to one gallon of the aforesaid solution of soda in water, add of rape oil, one gallon; and of tallow or palm oil, one quarter of a pound. Heat them together, to about 210° of Fahr. and then let the fluid composition be well stirred about, and agitated without intermission, until cooled down to 60° or 70°, when it will be of the consistence of cream. If it be desired thicker, a little addition of tallow or palm oil renders it so.

It has been observed that the deflection of the railway bars, by heavy carriages passing over them on the Manchester and other lines of road, absorbs a considerable portion of the tractive force; besides producing, by their vibratory action, an earlier destruction of the stationary, as well as the locomotive mechanism. To provide a remedy for these apparent defects of the *ordinary system*, Mr. John Reynolds, of Neath, has proposed to give to the *rails, bars, or plates*, an equal support in every part of their length, so that they *shall not be susceptible* of depression or deflection; and this he proposes to *effect by two methods*, for which he obtained a patent on the 5th May, 1835. The

first is by cast-iron bearers laid and joined end to end, and in such manner as to be incapable of vertical or lateral movement, independently of those next adjoining to it. The rails, bars, or plates, over which the carriage-wheels are intended to run, may be either cast on and with the bearers, or they may be separate. The second method is by bearers formed by blocks of natural or artificial stone, joined end to end, and bedded in the roadway, and secured in such manner together, that they can only move in concert. A great variety of forms of rails, founded upon the basis of construction just mentioned, have been made by Mr. Reynolds: it will only be in our power to notice here two or three of them. The annexed figure shows a vertical section of one of the most approved forms, in which the *ballasting* that it is imbedded in, shown at *a a*, is of less depth than the bottom of the stone sleepers generally used, and of considerably less depth than the bottom of the excavation and ballasting on the London and Birmingham railway.



The form of the bearing rail for the carriage wheels is shown at *b*, and that of the hollow support and lateral inclined plates at *c c*. They are fastened end to end by means of "snugs," or projecting pieces cast to them, of such forms as that, when placed in juxtaposition, a key or wedge is driven into an aperture formed by their union, which holds them firmly together. The blocks of natural or artificial stone are to be joined by the various modes known to masons, and the iron rail above, whether of wrought or cast iron, are also to be fastened by means equally well understood to need explanation. The annexed section represents another cut of the numerous designs given by the patentee: *w* represents a wrought-iron rail, resting upon and fastened to a sill of timber *t*, enclosed between the bearing plates *g g*, which, together with the fin *d*, are imbedded in the ballasting.



The advantages contemplated by the patentee are—1, a great saving in excavation and ballasting; 2, a saving of the cost of materials and laying down; 3, in maintenance of way or permanence of work; 4, saving the repairs of engines. Some rails on this construction are laid down experimentally on the Liverpool and Manchester line, and apparently stand the test very satisfactorily.

Mr. Thomas Parkins, of Dudley, has had a patent for a similar object to the foregoing, which is dated the 3d of December, 1835. It consists in forming continuous sleepers of vitrified earth (burnt clay), which the patentee states are as hard and durable as granite, and impervious to the weather. The following *Fig.* 1 gives a cross section of Mr. Parkins's railway, and *Fig.* 2 a side elevation of a portion of it. The vitrified blocks or sleepers are shown at *a a a*; each sleeper is 13 inches at the base, five at the top, twelve deep, and nine long, and locks into the other, thus forming a continuous mass along the whole line of road. The *joining is effected* by a projecting tongue b, which fits into a corre*sponding recess made in* each block. A groove c is moulded longitudinally in *the top of the sleepers*, into which the rib of a wooden bearer d (four inches at

the base, four deep, two wide at the top, and twelve feet or more long) is placed; and is bedded upon patent felt; on this wooden bearer is fixed an iron bar *e e*, for the wheels of the carriages to run upon; this bar or rail being also bedded upon felt.

Fig. 1.

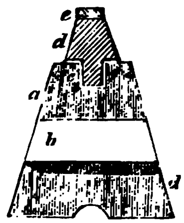
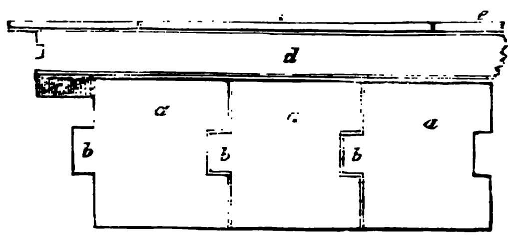


Fig. 2.



Mr. Parkins gives the preference to the arrangement described; but he proposes, in certain cases, to dispense with the wooden bearers *d d*, and to place iron rails of the ordinary kind at once into the groove *c*.

A variety of novel combinations of mechanism for steam carriages were patented on the 6th Dec. 1835, by Mr. W. Carpmael, of Crawford-street, as the agent of a French gentleman. In the space which we can devote to notice it, it would be quite impracticable to convey an intelligible idea of the numerous ingenious contrivances the specification sets forth; we shall, therefore, merely state, that the boiler consists of two parallel rows of large vertical tubes for the water, so placed in a quadrangular case, as to divide it into three compartments, the middle one of which is the largest. In this middle chamber is put the fuel, coals; and in the two small chambers in the other sides of the two rows of tubes, is put another kind of fuel, coke. The combustion of the coals is excited by a fan-wheel, placed under the grating of the coal chamber, and the smoke and other inflammable matter that escapes from this fire-place is conducted between the tubes and over the coke fires, by which arrangement the smoke and carbonaceous matters will, it is fairly presumed, be inflamed, and the caloric thus extricated be beneficially employed in the generation of steam. The steam chambers, consisting of capacious horizontal tubes, close up the tops of each of the furnaces; and the steam is conducted through regulating valves and pipes to the engines situated in the bed of the carriage frame. Many of the subordinate contrivances exhibit considerable mechanical talent, and afford pretty strong evidence that our Gallic friends will soon run a race with us by steam.

Mr. John Blyth, a young engineer of excellent abilities, residing at Limehouse, obtained a patent on the 31st of December, 1835, for "an improved method of retarding the progress of carriages in certain cases," which is extremely simple and effectual. It consists of a friction wheel, fixed on to the inner side of the nave of the running wheel (or wheels); around this is brought a friction band, and hence it is conducted and made fast to the carriage body, in such manner that when descending a hill or inclined plane, the carriage body slides forward and draws the friction band against the friction wheel. The natural force of gravity is thus admirably employed to counteract its inconveniences "in certain cases;" and it will be observed that the force of retardation will be exactly as it is required; that is, in proportion to the inclination of the plane on which the carriage is descending.

To obviate that lateral and serpentine motion of railway carriages, arising from the ordinary construction of the "buffing apparatus," we have already, a few pages back, described the invention of Mr. Bergin. Another invention, designed to effect the same object, has been recently introduced by the intelligent Mr. Henry Booth, of Liverpool, for which that gentleman obtained letters patent dated the 23d of January, 1836.

The following engraving, *Fig.* 1, shows the mode in which railway carriages have usually been attached to each other by a simple chain, the buffers of one

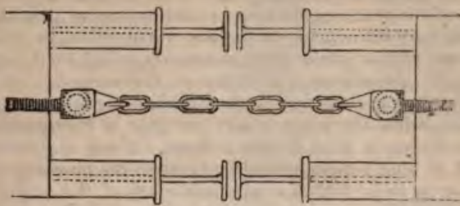


Fig. 1.

carriage not coming in contact with those of another, but each carriage being allowed, when moving onwards, a lateral oscillating motion. *Figs.* 2 and 3, show Mr. Booth's method of connecting them; *a* is the connecting chain attached to the draw-bar of each carriage, and consists of a double working screw (working within two long links or shackles), the sockets of which are spirally threaded to receive the screw bolts, which are fastened together by a

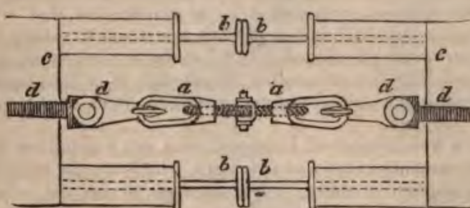


Fig. 2.

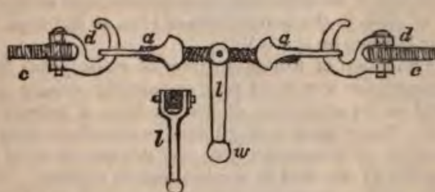


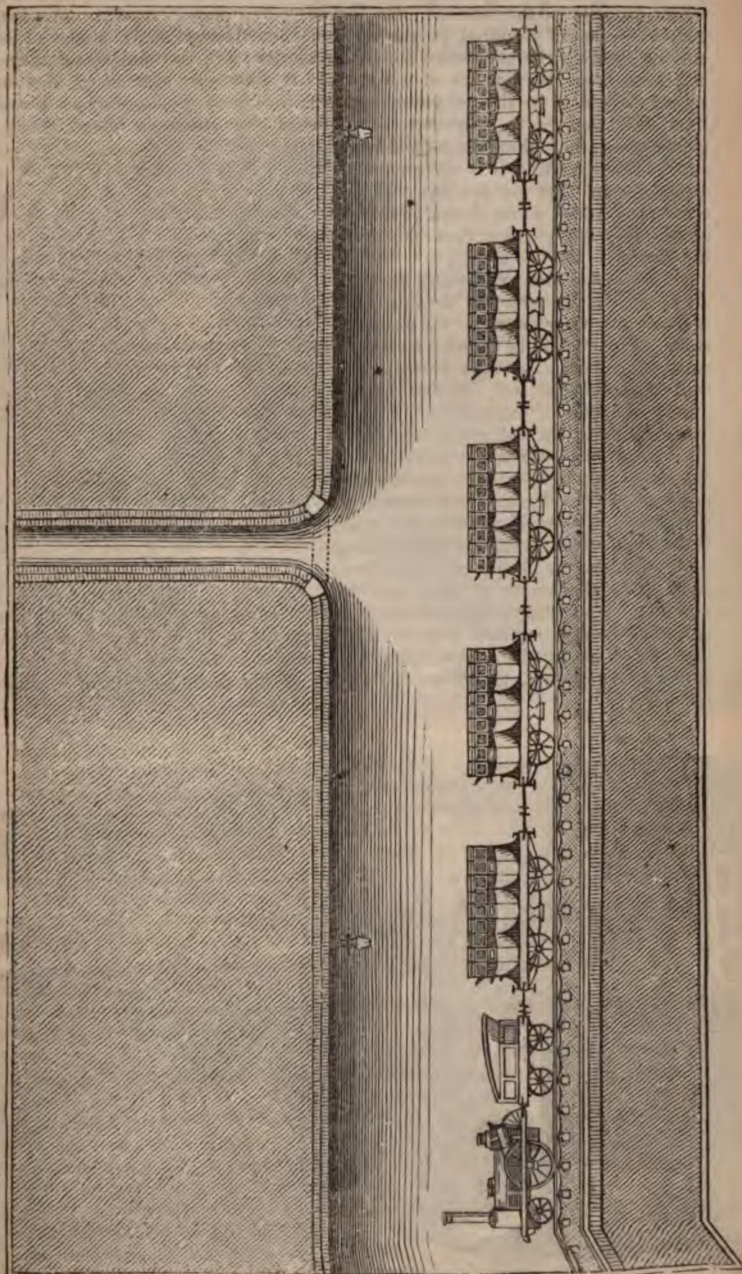
Fig. 3.

pin and cotter, so that by turning the arm or lever Z of the said screws, the connecting apparatus is lengthened or shortened at pleasure, to the extent of the long links or shackles above alluded to, in which they work. This screw-chain being placed on the hooks, or turned up ends of the carriage draw-bars *d*, the buffers *b* of each adjoining carriage being first brought close, or nearly close together, the lever Z is turned round a few times till the draw-bars *d* are drawn an inch or two beyond their shoulders, on the face of the carriage frame *e*, stretching the draw-springs, to which the draw bars are attached, to the extent of a fourth or fifth part of their elasticity; and by that degree of force attaching the buffers of the adjoining carriages together, and giving by this means, Mr. Booth states, "to a train of carriages, a combined steadiness and smoothness of motion at rapid speeds, which they have not when the buffers of each carriage are separate from those of the adjoining carriage." *w* is a weight to keep the lever in a vertical position, and prevent the unscrewing of the chain when in action. The patentee does not claim under this patent the parts described, separately considered; but he claims their combination and joint action, and "the consequent *close* but elastic attachment of the carriages to each other, *which constitutes my* improvement applicable to railway carriages."

The same patent includes a very pretty and useful contrivance of this original-minded inventor, which is thus described by him:—"And my improvement applicable to the locomotive engines which draw the railway carriages, I declare to be a new mode of checking the speed of the engine, or stopping it altogether, which is effected by introducing a throttle valve, slide, or damper, into the exhausting steam pipe of the engine, commonly called the blast pipe, which is usually placed in the chimney in front of the engine, and which throttle valve may be most conveniently introduced when the two exhausting pipes are united into one below the place where the pipe is contracted in area for the purpose of producing a blast to the furnace. From the throttle valve must proceed a rod or long handle extending through the chimney to the back part of the boiler, so as to lie within convenient reach of the engine-man, who, by moving the said handle, can close the slide or throttle valve, either partially, or altogether, as may be required. And the throttle valve need not be altogether steam-tight, but should be made to work freely in its place. The engine-man, when he wishes to stop or slacken the speed of the engine, closes or contracts his throttle valve without shutting off the steam in its passage from the boiler to the engine. The pistons, by that means, are speedily, but not suddenly or violently checked, and the driving wheels of the engine no longer revolving, or revolving very slowly, the engine is soon brought to a stand. Now I do not claim, as new, any particular kind of throttle valve, which may be left to the judgment of the engineer, provided it be so constructed that, when open, the steam may be not contracted, but may allow the steam to escape freely, as if no valve or damper were introduced. But I claim the introduction of a throttle valve or damper into the exhausting steam-pipe of a locomotive engine, by closing or contracting which, the engine-man can check or stop his engines at pleasure."

Mr. Massey, a watchmaker of Liverpool, took out a patent on the 23d April, 1836, for improvements in railway carriages, which merely consists in dividing the usual quadrangular framing of the carriage, across the middle, into two parts, making two smaller complete frames, and connecting the ends of these midway by a stout bolt, with a cotter-key, and washers, so as to enable the frame of the carriages to yield to the inequalities of level in the road, and not lift the wheels from their bearing on the rails.

Tunnels.—The adoption of tunnels in lines of railway has been the subject of much discussion; for the most part apparently arising from individuals who are interested in the execution of certain lines of railway, in which tunnels are excluded. Many timid and ignorant persons have thus been frightened into the apprehension of suffocation from the noxious state of the air, caused by the decomposition of the fuel in the locomotive engines. In order to show to what extent the air in a tunnel is thus contaminated, Mr. Gibbs, in his report already alluded to, observes: "Let us suppose a tunnel one mile in length, to be traversed by a locomotive engine and its train, of a gross weight of 100 tons. The experience of the Liverpool and Manchester railway has shown that the average consumption of coke is considerably less than *half a pound per ton for each mile* it is carried on a railway; but taking the consumption at half a pound, the whole weight of 100 tons will require the consumption of 50 lbs. of coke. It may be calculated that every ten pounds of coke will evaporate a cubic foot of water; so that the whole 50 lbs. will convert into steam five cubic feet of water in the distance of one mile. Now, to convert into steam one cubic foot of water, requires 1950, or say 2000 cubic feet of air; then five feet of water will of course require 10,000 feet, and this will be the whole amount of contaminated air in one mile of tunnel. To determine the proportion of such an amount of foul air, and the whole of the air contained in the tunnel, we may take, for example, a moderate sized tunnel, 30 feet high, having an area of 800 square feet. One mile in length of such a tunnel, will contain 4,224,000 cubic feet; hence the contaminated air will bear to the whole quantity in the tunnel, the ratio of 10,000 to 4,224,000, or it will be as 1 to 422. It will scarcely after this, appear any valid objection to tunnels, to assert that an injurious effect must result from the contaminated air, when we find that the quantity of this description of air



produced by the passing of the whole train will be no more than $\frac{1}{423}$ part of the whole quantity in the tunnel." On the preceding page is represented a longitudinal section of a tunnel, (supposed to be cut through marl, shale, or clay strata,) showing the proportion which an engine with its tender and train of carriages bears to the size of a tunnel. A transverse section of the same tunnel is given in the subjoined figure; in which the irregular diagonal lines are intended to represent the form of the strata in marl, shale, or plastic clay. In making tunnels through strata of this nature, it is an important consideration that no springs will encroach; on the other hand, inverted arches become necessary, as shown in the figure.

In the formation of tunnels through chalk rocks, the expense is less than through any other material; the excellent stone of which it is usually composed renders artificial side walls unnecessary, while the material will, in some cases, exceed the cost of excavation. "As to the expediency of adopting tunnels at all," Mr. Gibbs observes, "it is certain that this ought not to be admitted until after much consideration and investigation, with a view if possible to avoid them; yet when, by the introduction of a tunnel a positive good might be effected, such as a shortening of the line, the means of penetrating a difficult summit, or of reaching a country which might otherwise be shut out from the advantages offered by the railway, it might possibly be great injustice, alike to the shareholders in the undertaking, and the surrounding district, to adhere too rigidly to the determination of excluding tunnels."

The engraving on the preceding page represents a view of the Dublin and Kingstown Railway, as seen from the Black Rock

The subjoined engraving is another view of the same railway, passing through Lord Cloncurry's estate, and looking towards Kingstown.

Gradients.—The most important consideration in the construction of railways is the arrangement of the gradients. To effect this arrangement, two distinct and opposite systems present themselves, each having its advocates ready with arguments in support of their particular theory. In the one system, the rises and falls are distributed over the whole length of the line, in planes of gradual inclination; while the other proceeds on the principle of concentrating the acclivities in a few points, and thus gaining the summits at once, by short and steep inclined planes, at the same time obtaining levels throughout the rest of the line. To decide which of these systems is the most judicious, an investigation of the principles connected with the laws of retardation becomes necessary.

In Mr. Gibbs's *Report upon the several proposed Lines for the Brighton Railway*, this subject has been examined and illustrated with great simplicity and ability: to this *Report* we therefore with pleasure refer our readers, contenting ourselves with giving the results of his investigations; which are these:—

First, That on a series of railway inclinations, the power required to transport a weight from one given point to another, is precisely the same whatever inclinations are adopted, provided none of these inclinations exceed 21 feet in a mile, which is the limiting slope of a plane, on which the force of gravity becomes equal to, and consequently capable of balancing; or by any increase, of overcoming the retarding force of friction.

Second, On any series of inclinations, the power required to transport a *weight both ways*, is exactly equal to the power required to convey the goods *on a level plane.* This must be clear if we consider that a certain amount of

These we hope to be able to place before the public, together with some important matter relative to the theory of the subject, as well as the actual practice of our railway engineers, which we are reluctantly obliged here to [illegible]. We had also in preparation for the engraver a series of views, with plans, elevations, and sections of several of the great works now rapidly progressing in the various parts of the kingdom; also some beautiful designs for bridges, tunnels, and other railway works, which have been kindly furnished us by that eminent artist and engineer, Mr. Jones, of No. [illegible], St. Martin's-place, Charing Cross. This gentleman has lately proposed the employment of a spacious carriage, to accompany the trains, fitted up with all the conveniences of a steam-boat, for the accommodation of the infirm or sick.

ANALYTICAL INDEX.

R. CLAY, PRINTER, BREAD-STREET-HILL.

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